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ABSTRACT

This report describes a pilot energy conservation project in Grande Prairie (Alberta) School District No. 2357. Extensive data collection and analysis were undertaken to provide a sound, quantitative basis for evaluation of the program. Energy conserving measures requiring capital outlays were not considered. During the project, electric demand was reduced by 14 percent and electricity consumption by 25 percent. A 5 percent reduction in natural gas utilization was achieved through more efficient operation of plant by custodial staff and by improved maintenance. The procedures followed are described in detail. Recommendations to other school systems setting up an energy management program are that (1) specialized expertise is required; (2) the support and cooperation of all school personnel (including senior district administrators and custodial and maintenance staff) is necessary; and (3) an energy use monitoring program based on daily energy meter readings is necessary both to control performance and to stimulate awareness. (Author/MLF)

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AN ENERGY MANAGEMENT PROGRAMME
FOR
GRANDE PRAIRIE PUBLIC SCHOOL DISTRICT

A Research Project for
Alberta Education
and
Grande Prairie School District No. 2357

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October 1979

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INTRODUCTION

Since 1973, prices for electricity and natural gas have risen sharply. Due to this price escalation, Alberta school systems now spend about $23 million each year on these two utilities (1979). Because the rate of increase in energy prices is expected to remain high, reduced consumption is necessary to counteract the inflationary trend in energy prices.

This study of energy management for school buildings originated with a decision by Alberta Education to sponsor a pilot energy conservation project in Grande Prairie School District No. 2357. The Grande Prairie Board subcontracted the research work to a team from the University of Calgary's Faculty of Environmental Design. Research work was to exclude energy conserving measures requiring capital outlays.

The goal of the project was, as stated in the research proposal, "to develop an energy management programme which will minimize energy consumption in Grande Prairie School District Facilities while maintaining an environment conducive to the teaching process". The project team was to:

(i) Assess energy use in the Grande Prairie School District facilities;

(ii) Develop a management programme aimed at improving energy performance in the Grande Prairie School District facilities;

(iii) Implement, monitor, and evaluate specific measures for improving energy performance in various buildings in Grande Prairie School District;

(iv) Use the information gathered during the project to estimate savings attainable in buildings such as the ones under study;

(v) Integrate the results of this study with those underway elsewhere in Alberta concerning school building design and retrofit (physical upgrading);

(vi) Prepare a report on the project for distribution to Alberta school districts and other agencies.

The first year of the project was spent in analyzing energy use, testing conservation measures, conducting a literature search, surveying energy use in Alberta school systems, and developing the energy management concept. The second year of the project was spent in implementing a comprehensive energy management programme for Grande Prairie School District No. 2357.

This report is divided into two major sections. The first deals with the basic concepts of energy management for schools - principles and approaches proven through experience. The second describes the development of energy management techniques in Grande Prairie Public School District. Project results show that significant dollar and energy savings can be obtained through energy management.

ENERGY MANAGEMENT IN SCHOOL SYSTEMS: BASIC CONCEPTS

Energy management is a process of economic rationalization. Economically efficient use of energy requires that consumption be reduced to the point where the cost of saving one more unit of energy becomes greater than the cost of using one more unit of energy. Through energy management, expenditures for energy are reduced using cost effective techniques. In reducing expenditures, various constraints must be taken into consideration. These constraints include human comfort, statutory regulations, and various cost factors, including capital, labour, and purchased energy. Training and management of personnel is a critical consideration in energy management.

It should be noted that since this study was concerned with measures not requiring capital expenditures, neither retrofit (building modification) nor new construction are dealt with in detail, although both would be included in a comprehensive energy management programme.

Energy conserving measures should conform to two criteria: firstly, they should not impair the functioning of a building, and, secondly, they should offer an economically attractive return. Present energy price trends are dramatically increasing the economic attractiveness of conservation measures.

Within certain limits, capital and operating costs for a building can be "traded off". Life-cycle costing techniques should economically allocate expenditures between capital and operating budgets when buildings are designed. However, uncertainty and other factors can seriously complicate economic allocation (as the unexpected shift in energy prices since 1973 has shown). As a result, subsequent reassessment may become necessary. Unfortunately, taking corrective action can present difficulties. For example, adding two centimetres of insulation to a roof in the design phase adds little to construction labour costs; adding the same two centimetres to an existing building involves high labour costs. The economics of upgrading the energy performance of existing buildings leads to somewhat different problems than are involved in designing energy efficient new construction.

Before discussing approaches to increasing the energy efficiency of buildings, principles of environmental control for human comfort in buildings must be reviewed.

1. HUMAN COMFORT

Buildings should be constructed so that the occupants are subjected to an economic minimum of disturbance by the natural environment. Extensive research has therefore been invested in the definition of conditions for human physiological and psychological comfort. By utilizing scientifically defined criteria, architects can design enclosure systems and environmental control systems that will meet these requirements. The same criteria can be used to assess whether performance of an existing building is adequate.

Comfort criteria are based on averages of human reactions to environmental conditions as measured in laboratories. Varying individual preferences prevent the definition of a single "comfort situation". The most optimal set of environmental conditions will satisfy up to 90 percent of a typical group of individuals. In practice, each individual is the best judge of his own comfort.

Most notable in establishing standards have been the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE, 1977) and the Illuminating Engineering Society (IES, 1972). Standards exist for thermal comfort, illumination levels, ventilation rates, humidity, and noise.

Comfort conditions vary with activity, attire, and age. They also depend on physiological and psychological characteristics of the individual. Typical standards specify 22 to 25 °C room temperature (ASHRAE Standard 55-66), 0.019 m^3/sec/person ventilation (ASHRAE Standard 62-73), and 300 to 1100 lux (30 to 110 footcandles) of illumination (IES, 1972); these examples provide some indication of the types of criteria used to specify adequate conditions.

A much more detailed knowledge of principles and guidelines is required for competent design. In ensuring adequate ventilation, it is also necessary to avoid creating drafts. In ensuring thermal comfort not only air temperature, but also temperatures of wall surfaces must be considered (so that people do not radiate excessive heat to exterior walls in winter). In providing comfortable lighting, not only the gross level, but also glare and shadow must be considered.

Temperature levels, lighting levels, and air quality affect both energy consumption and human comfort (McNall, 1976). Excess levels of service provided over several hundred hours per year can be a needless energy expenditure. Remedying insufficient levels of service can increase human health and productivity. Many Canadian buildings do not meet recognized standards, either through excess or deficiency. Matching of performance to standards to improve energy efficiency has been extensively documented (Dubin, 1976).

1.1 Lighting Standards

A more controversial aspect of guidelines is their validity. Illumination guidelines are the most intensely disputed standards for environmental control. Proponents of higher illumination levels argue that they increase human productivity, while proponents of lower illumination levels maintain that increments in productivity dwindle rapidly above 200 lux (20 footcandles). With the marginal cost of providing increasing levels of lighting rising sharply and the marginal benefit of more illumination tapering off at higher levels, critical re-examination of standards is tending to favour a less energy consumptive tradeoff. Classrooms in Britain, for instance, are designed to provide 300 lux compared with the IES recommended minimum of 750. For spaces which are mechanically cooled, the energy cost of high lighting levels is compounded by heat loss from lights. Richard Stein (Stein, 1976) presents many of the arguments against the high levels of illumination specified in IES lighting standards.

Research funded by the General Services Administration (GSA) in the United States has also contradicted IES sponsored findings. Although some school districts have moved to even lower levels (Thomas, 1976), standards recommended by the GSA (Wotton, 1976) were adopted as minimum average levels for Grande Prairie schools:

(i) Workplace - 540 lux (50 footcandles)(planar)
(ii) Background - 320 lux (30 footcandles)(planar)
(iii) Corridors - 110 lux (10 footcandles)(planar).

Implementation of these standards was a major source of energy and dollar savings in Grande Prairie.

Many factors enter into high quality illumination apart from lighting levels; one must also consider shadow, glare, and light distribution. These are discussed by Stein, Wotton, and other authors. Care was taken to ensure they were considered when making modifications in Grande Prairie.

1.2 Temperature Standards

The temperature levels maintained in a building are also a major determinant of energy consumption levels; manipulation of these levels can save energy. ASHRAE standard 55-74 maintains that "normally clothed adults engaged in office activity" are comfortable between 23 and 26 °C at low relative humidity. Other sources show optimal comfort for Canadians occuring at 21 °C (Olgyay, 1963). The British comfort zone has been shown to range from 15 to 21 °C (Brooks, 1956)! Scientific experiments have demonstrated that sedentary job performance and comfort are actually improved when the ambient temperature is reduced to levels in the vicinity of 20 °C (Reddy, 1976). Again, the standards vary, and the literature must be consulted for more detailed analysis of the causes.

The temperature at which most people will be comfortable can be shifted higher in summer and lower in winter by removing or adding clothing. For a man dressed in a warm suit the comfort zone lower boundary may lie around 18 °C; for a man dressed in a light suit, the comfort zone upper boundary may lie around 26 °C (McNall, 1976). This flexibility can be used to reduce cooling and heating requirements in summer and winter respectively.

1.3 Summary

Human comfort standards are necessary for protecting health, for guiding plant operation when control is not decentralized, and for general purposes of specification. The best guide to human comfort will be the acceptance of conditions by users. Gaining this acceptance requires interaction between the user and the energy management specialist so that guidelines are applied with insight into local conditions. This may sometimes be as much a psychological as a physiological acceptance. Requirements for human comfort must be satisfied when adjusting building operations.

2. ENERGY EFFICIENT SCHOOLS

There are three criteria for judging whether schools are energy efficient:

(i) they should, when occupied, meet requirements for human comfort (that is, the application of energy should be effective);

(ii) they should be able to meet these requirements with an economic minimum of purchased energy (that is, the application of energy should be cost effective);

(iii) they should, when vacant, use the economic minimum amount of energy possible without incurring damage (such as freezing of pipes).

There are three ways schools can be made to satisfy these criteria:

(i) replacement by new specially designed buildings;

(ii) physical upgrading (e.g. addition of insulation);

(iii) improved operation (e.g. removal of excess lighting).

2.1 New Buildings

The Edmonton Board of Education is currently experimenting with the construction of an energy efficient school. It has been designed to require less than 28.5 W/m^2 (250 kWh m^{-2} yr^{-1} - annual average rate of energy use per unit of gross floor area: 1 W/m^2 equals 8.8 kWh m^{-2} yr^{-1}), the federal government's suggested maximum consumption rate for new buildings (Alberta schools typically use from 40 to 75 W/m^2 (350 to 660 kWh m^{-2} yr^{-1}), with 56 W/m^2 (490 kWh m^{-2} yr^{-1}) being average, according to surveys carried out by the Environmental Design research team). Post-occupancy evaluation of this energy efficient school is currently being undertaken. The findings of the Edmonton project should benefit school systems which have to add to their facilities in the future.

Given the rate of growth of the school building stock, however, it is evident that existing buildings will dominate in determining the overall energy efficiency of the school building stock for the next twenty years. Replacement of existing schools by more energy efficient buildings will therefore be a very long term process. When school systems must demolish buildings, consideration should be given to phasing out the least efficient buildings in the system.

2.2 Physical Upgrading

A detailed study has been carried out by the Calgary Board of Education on retrofit (physical upgrading) of existing facilities to reduce their energy requirements. Possibilities investigated included addition of insulation, modification of mechanical systems, and use of automatic controls. The major conclusion was that major energy savings from other than automatic controls could be accomplished only with large capital expenditures. It was further concluded that the physical changes investigated were not cost effective for the schools studied. The question of the cost effectiveness of physical upgrading is discussed in more detail in Chapter 12.

2.3 Improved Operations

There are three approaches to improving the efficiency of operations:

(i) reducing the period over which a system (such as air-conditioning) must operate will usually reduce energy requirements;

(ii) reducing the rate (level of operation) at which a system must operate will usually reduce energy requirements;

(iii) increasing the effectiveness with which a system can perform its function will usually reduce energy requirements.

The building systems to which energy conservation measures may be applied are as follows:

(i) enclosure systems (walls, windows, and roofs)

(ii) space heating systems

(iii) lighting systems

(iv) space cooling systems

(v) control systems

(vi) domestic water heating systems

(vii) circulating systems (ventilation air, domestic water)

(viii) auxiliary systems (car plug-ins, shop, office, audiovisual)

(ix) humidification systems.

Enclosure systems and control systems consume the least energy directly but are the most important systems in reducing energy consumption. By reducing heat loss, heat gain, and air leakage, a well-maintained enclosure system significantly reduces the mechanical work required of other building systems.

Control systems govern environmental control system operation, permitting precise regulation of conditions such as temperature and illumination. It is important that they be accessible, functional, and calibrated as accurately as possible.

Types of energy conserving measures applicable to building operation will now be discussed in more detail.

2.3.1 Period of Operation

As stated above, reducing the period over which a system must operate will tend to reduce energy requirements.

Instructional days in schools number between 190 and 200; at 9 hours of use per day, this amounts to less than 25 percent of the 8766 hours in a year. For two summer months each year only custodial and maintenance staff may have access to the buildings. During the winter, school rooms may lie unoccupied for 12 to 24 hours per day; at times, these spaces are unoccupied for up to a week. These unoccupied periods allow a relaxation of tolerances for interior comfort conditions, thus creating a potential for energy savings (ventilation is not required, and warmer or cooler temperatures are acceptable, although some heating during the winter is still necessary to ensure durability of building systems and components).

Community use may add to the number of hours when conditions for human comfort must be sustained. This is not meant to imply that community use of schools should be discouraged. The reverse is true from a community plannning standpoint. Increasing the intensity of utilization of public buildings can be a very significant means of conserving both energy and capital. The incremental energy costs of these additional hours of use are usually quite small.

2.3.2 Level of Operation

The rate of doing work (power) multiplied by the time over which the work is performed determines the energy consumption. Reducing the level of operation at which any building equipment must operate will usually tend to reduce annual energy requirements. It can also reduce the peak power demand on which electrical utility charges are based. Such reductions may be possible if a system is over-performing or if output demands on the system can be reduced. Reducing excessive ventilation rates is a major energy conserving measure of this type.

2.3.3 Efficiency of Operation

The less energy a system requires to perform a given task, the more efficient it is. Problems such as collapsed or blocked ductwork may prevent hot air from reaching its destination, even when furnaces are operating at full capacity. Corroded heat exchangers in furnaces may prevent the heat value of fuel from being fully utilized. Even simple measures such as lubrication contribute to efficient operation. Proper maintenance of equipment reduces overall energy requirements.

Buildings are frequently operated by individuals lacking a full understanding of the installed equipment, resulting in excessive consumption. This problem was encountered with some consistency in this study, and has been mentioned by others (Saunders and Smith, 1976). Operator training can lead to significant improvements in energy performance.

3. PLANNING FOR ENERGY MANAGEMENT

Energy management programmes should be designed to yield the greatest returns possible for the effort and money expended. The steps in initiating an energy management programme are:

(i) appoint an energy management coordinator for the school system;

(ii) analyze energy utilization and identify potential savings in energy expenditures;

(iii) analyze the local organizational environment and manpower capabilities;

(iv) design an appropriate energy management programme;

(v) provide basic instruction to staff on energy management - the why's and how's of conservation;

(vi) implement energy management as a permanent function;

(vii) implement specific energy conserving measures.

This chapter deals with analyzing energy utilization.

3.1 Uses of Energy

Table 3.1 provides some basic climatic information for some North American locations. It is evident that cities in Alberta are exposed to relatively low average temperatures. Buildings in this province may also be designed and constructed differently than those in other places. This means that techniques used to conserve energy in other parts of North America may not be directly applicable in Alberta.

Table 3.1. Climatic information for selected North American sites.

Location	2.5% Design Temperature (degrees Celsius) January	July	Mean Daily Temperature (degrees Celsius)	Average Celsius Degree-Days(*)
Grande Prairie	-38	27	1.5	6100
Edmonton	-32	28	2.7	5700
Calgary	-31	29	3.9	5300
Lethbridge	-31	31	4.8	4800
Medicine Hat	-32	33	4.5	4900
Ottawa	-25	30	5.3	4800
Washington D.C.	-7	33	12.2	2700

* 18 °C is the base temperature.

Table 3.2. Energy consumption rates for selected Alberta school systems (based on reported 1977 data).

School System Code	Energy Utilization (W/m^2) Natural Gas High			Electricity		
	High	Average	Low	High	Average	Low
1.	78	54	28	6.9	4.2	2.3
2.	290	170	140	14.4	11.2	6.9
3.	54	46	38	9.7	5.8	3.1
4.	82	52	14	4.7	3.2	2.1
5.	82	63	50	8.3	5.9	4.3
6.	54	49	32	11.6	4.8	0.4
7.	68	47	27	4.8	3.9	2.0
8.	42	37	26	9.5	5.1	1.9
9.	73	40	23	6.7	2.5	1.4
10.	96	47	22	13.1	8.6	4.9
11.	50	33	18	2.1	1.6	1.1
12.	64	38	26	27.9	6.5	4.9
13.	68	46	33	12.3	9.9	8.4
14.	46	40	22	6.5	5.1	2.1
15.	81	51	35	16.0	11.2	3.7
Grande Prairie	74	48	38	12.1	8.2	1.0
Grande Prairie RC	61	56	39	4.7	4.4	3.6
AVERAGES	68	50	30	10.3	6.0	3.1

Notes: Systems #2 and #11 are not included in the averages due to apparently unreliable reporting of data by the school systems.

Table 3.2 summarizes energy requirements of some Alberta school systems which were surveyed in 1978. A two to three fold variation is evident between high and low consumption rates in each school system (this applies to both electricity and natural gas).

Since every building is different, some caution must be used in making general statements about patterns of energy use. The following generalities are based on the research team's observations of some typical Alberta schools:

(i) space heating accounts for almost 100 percent of natural gas consumption in most Alberta schools - many do not even have cooling systems;

(ii) lighting accounts for almost half of electricity consumption and operation of fan motors for a like amount;

(iii) roughly two thirds of natural gas and one third of electricity consumed are used when schools are empty.

Potential energy savings will depend on the types of systems installed in buildings, the condition of these systems, and present operating schedules. Analyzing energy utilization involves five activities:

(i) calculation of present energy consumption rates;

(ii) examination of the building envelopes and preparation of an inventory of equipment (to be compiled for heating, ventilating, air-conditioning, lighting, domestic hot water, controls, and metering equipment - data to be collected would include model, type, location, age, capacity, and condition);

(iii) obtaining schedules of operation for physical plant (including daily, weekly, monthly, and seasonal cycles);

(iv) determination of use patterns for the buildings;

(v) examination of energy utility service tariffs.

Electricity and natural gas service tariffs are as important a consideration as actual levels of energy consumption in planning an energy management programme.

3.2 Energy Pricing

Energy prices vary widely throughout Alberta. The 1978 prices for electricity varied from $5 to $27 per GJ (1.8 to 9.7 cents per kWh), while those for natural gas were in the vicinity of $1.00 to $1.20 per GJ (about $1.00 to $1.20 per MCF). Obviously, electricity is far more expensive to the consumer than natural gas.

Natural gas service is provided to the customer for a small monthly service charge (about $5) plus a charge per unit of fuel consumed.

Billing for electricity is more complicated. It is based not only on the amount of electricity consumed per month (energy), but also on the maximum demand for electricity which occurs at any point over a long period - usually a year. This maximum demand is called the peak power demand, or peak demand. It is used in billing because electricity, unlike natural gas, cannot easily be stored in large quantities. The electric utility must have enough generating and transmission equipment installed to meet the peak demand of its customers even if this demand occurs only once each year. A billing formula, approved by the Public Utilities Board, is used to calculate total monthly charges for electricity.

Another factor in electrical billing, which may affect some schools, is the power factor. Inductive loads, such as electric motors, cause a phase shift between voltage and current. When such a phase shift occurs, some useful electric power is lost. The utility penalizes the customer for any excessive phase shift it causes by applying monetary penalties. The power factor is a measure of the phase shift; the worse the phase shift, the lower the power factor. Power factors vary between 0.0 and 1.0. Power factors above 0.9 are usually considered to be adequate. Compensating equipment can be installed if the power factor is too low (information about the power factor for a building and local power factor penalties can be obtained through the local electric utility).

3.3 Monetary and Energy Savings

As is evident from the forgoing discussions, reductions in energy consumption cannot be directly translated into dollars. Utility service tariff structures must be consulted to estimate potential dollar returns from conservation efforts. Because of regional variations in energy prices, the economic attractiveness of energy conservation measures may vary somewhat from city to city in Alberta.

The information from the energy use analysis provides a sound basis for design of an appropriate energy management programme. This should include a financial and time plan for the implementation of conservation measures, and a schedule of conservation measures to be implemented. A formal organizational framework for energy management is also necessary.

4. BEHAVIOURAL CONSIDERATIONS IN ENERGY MANAGEMENT

Motivation and management of personnel is a key element of energy management. Disgruntled employees have been known, in isolated instances, to sabotage energy management efforts for various reasons. The proper approach to human relations in energy management helps to maximize energy savings. This chapter presents some of the behavioural considerations in energy management.

4.1 Training of Staff

Expanding the responsibilities of employees and increasing their competence at fulfilling responsibilities requires a substantial amount of contact time with energy management specialists. Employees must be educated to understand the need for energy management, the benefits of energy management, the principles and practices of energy management, and their own specific duties. While working with local staff, the energy management specialist can gain a better understanding of local concerns and problems. These usually stem not only from the physical plant, but also from staff characteristics and relationships.

Training requirements will vary with the role of the individual in the energy management programme. Intermittent contacts over as much as two years may be required. This amount of time is often required in any case to deal with organizational problems of the types discussed below.

The primary concern with teachers is ensuring that they understand the implications of the energy management programme for the classroom. Single training sessions for each school would probably be sufficient to outline the purpose of and procedures for energy management. Follow-up discussions led by the principal could be held at staff meetings to discuss current problems and progress, as is done for other ongoing school programmes.

Because the Board is the senior policy-making body in a school system, its support is essential for the energy management programme to succeed. School trustees should have an introductory session with energy management specialists, as well as follow-up presentations by the district energy management coordinator. Progress reports by energy management specialists may be needed on occasion.

Introductory sessions would be just the beginning point in direct training of administrative, custodial, and maintenance staff. Administrative staff should receive additional instruction on the managerial aspects of the programme - supervision, coordination, energy auditing, and financial planning. Custodial and maintenance staff should be taught about specific energy conserving measures. While a lecture format is satisfactory for initial contact, subsequent contact should take place in the individual's place of work. This promotes specific discussion of problems and opportunities with both administrators and custodians. Review of energy management techniques in the work place also provides the repetition necessary to thoroughly instil understanding.

4.2 Organizational Problems in Energy Management

In the course of the literature search and the field work, organizational obstacles to improved energy performance were identified.

4.2.1 Apathy, Inertia, and Ignorance

Some individuals may be unwilling to make an effort to conserve energy, small as the required effort might be. This may be attributed to apathy, inertia, or ignorance.

Ignorance is often the root problem - people do not realize that their individual efforts to conserve would really make a difference. In some cases, the problem is a more serious question of motivation. This is where the leadership role of senior administrative staff becomes crucial. Motivation is dealt with at some length in a following section.

Misinformation may also hinder efforts to conserve energy. Myths, such as the one that "turning off fluorescent lights doesn't save energy" must be debunked. Key staff should gain a correct understanding of physical plant operation and utility tariffs.

It is also important that all school system employees, as well as students, understand the general aims and methods of the energy management programme. A common misconception is that energy conserving measures cause discomfort. It should be made clear that levels of comfort are maintained or improved under energy management.

4.2.2 Lack of Leadership

Lack of leadership has been widely recognized as a factor where energy management programmes have not achieved their potential.

A common error on the part of senior school system administrators is delegation of the entire responsibility for energy management to maintenance and/or custodial personnel. These personnel do not have the authority to make principals and other staff in relatively senior positions respond to requests. The lack of immediate concern shown by senior school system administrators may in itself lead maintenance and custodial staff to assign the energy management programme a low priority. It is frequently the practice to delegate the entire responsibility for energy management to subordinate individuals, such as custodial and maintenance personnel. However, subordinate individuals frequently do not have the authority to make their colleagues take the energy management programme seriously. They may also be discouraged by the indifference often shown by senior educational administrators.

4.2.3 Loss of Enthusiasm Over Time

Energy conservation programmes are frequently initiated with much publicity and little substance. A rigorous management approach is required to ensure that the programme maintains its effectiveness. Monitoring and reviewing functions are essential in providing an indisputable, quantitative, and continuing check on performance.

4.2.4 Discontinuity of Personnel

With contemporary levels of mobility, positions are frequently filled by the same people for only short periods of time. The goals, procedures, and records of the energy management programme must be well documented so that continuity of performance can be maintained.

4.2.5 Resistance to Change

Many school system employees are already very busy people. They may resent the time demands posed by energy management. However, if the substantial benefits of a thorough conservation effort are to be realized, this resistance must be overcome.

4.2.6 Lack of Communication

Senior administrators should be aware of the detailed progress of the energy management programme in the school system. Misinterpretation of instructions or failure to implement instructions can disrupt the "chain of command". A typical example of communication problems is the failure by middle management to implement conservation measures suggested by staff in a particular school and endorsed by senior administrators. This leads to frustration of lower level staff and a failure to realize potential savings. Keeping track of energy management activities not only prevents such communication problems, but also provides senior administrators with a measure of organizational effectiveness.

4.3 Motivational Considerations in Energy Management

Senior administrators must be convinced that energy management is a worthwhile concern, and must be able to convince their subordinates likewise. This chapter deals with motivational aspects of implementing energy management.

The most direct and convincing motivation for conserving energy in schools is cost control. Money spent on energy is money not available for school programmes and improvements.

Within school systems it is the role of senior administrators to set policies and procedures for economic school operations. Persuing a goal of energy efficient operation therefore falls within their usual management jurisdiction.

Energy management is actually a classic management exercise of setting goals and mobilizing an organization to achieve them. By combining information on human motivation with some principles of management science, the following components of a motivational programme were formulated.

4.3.1 Awareness

As a price inflating effect, changing energy resource availability and values are experienced by school staff as consumers. This "background" awareness has to be sharpened to focus on the specific problems of the school district.

Employees of school systems have to be made aware that the cost of electricity and natural gas has become a major expense to the school system. They must be persuaded that levels of consumption can be reduced without major upset and that such reductions are a reasonable, necessary, and effective form of cost control. If an employee holds additional personal convictions favouring energy conserving behaviour, this will further motivate him. However, such convictions cannot be forced on people.

In most school systems, cost information on electricity and natural gas is not provided to school administrators on a regular basis. Many do not realize how significant energy costs are either for the school system or for their school. This lack of communication must be rectified (elementary schools alone typically have an energy requirement costing $10 000 to $20 000 per annum).

4.3.2 Incentive

Apart from knowing that a problem exists, staff members have to have incentives for taking appropriate action.

Administrators should have a professional commitment to efficient school system operation. The benefits to be realized by the organization should be adequate to attract their support for energy management. Other staff can be motivated by:

(i) giving efficient energy use the same priority as other concerns of comparable economic importance;

(ii) providing personal recognition for contributions to improved energy performance (to do this, administrators will have to be observant of day to day operations - but this is necessary in any case to avoid communication problems and to evaluate organizational effectiveness);

(iii) using data on building energy performance to provide staff with quantitative feedback.

Although some school districts have employed monetary rewards as incentives, these have serious drawbacks. Among the problems with such rewards are the difficulties of comparing energy performance, the difficulties of determining who should be rewarded and how much, and the costs of funding such rewards.

Other management objectives in school systems are met without special monetary incentives, and efficient energy use can be achieved in the same way. The latter approach avoids the problems inherent in a monetary bonus system.

4.3.3 Information

It is not enough to simply arouse the concern of employees regarding energy conservation - it is also necessary to ensure that they are made aware of appropriate responses. Otherwise the programme will be ineffectual.

In-service training on conservation measures and energy management will usually be required. Provision of basic instruction on the why's and how's of conservation is listed as the third step (after analyzing energy utilization and designing an energy management programme) in initiating an energy management programme (see Chapter 3). The assistance of specialist consultants would be necessary in providing this training.

4.3.4 Responsibility

Individual employees and departments alike must know precisely what their responsibilities are. General exhortations to conserve can be quite fruitless because they are not specific in directing and evaluating efforts. By delegating specific duties, it is readily possible to judge whether individual responsibilities are being met. This will also minimize counterproductive uncertainty and confusion.

The school system energy management coordinator can, with the assistance of a specialist, establish a hierarchy of responsibility for energy management.

4.3.5 Follow-up

As in any management exercise, continuing follow-up will be required to assess the effectiveness of the programme and to take remedial action where required. Problems may range from human to technical - for each type of potential difficulty, an appropriate means of detection and response must be established.

Consultative assistance may be required to provide both specialized expertise in resolving problems, as well as the perspective of the external observer (regular employees frequently do not recognize that a problem even exists).

The nature of the follow-up effort may vary with the size and functions of the buildings. An elementary school principal deals with fewer people and a smaller building; a high school principal has academic and administrative assistants, several custodians, and numerous departments to manage.

4.3.6 Feedback

Although a restatement in part of preceding articles, the following comments are important enough to merit redundancy. Each person involved in the energy management effort must believe that his participation is meaningful. People must have feedback on performance. The energy auditing system can provide information, but it must be widely disseminated to be effective.

More than information feedback is required, however; administrators must communicate their interest in the efforts and achievements. The process of familiarizing staff with energy management may require a couple of years of intermittent contact with consultants. Repeated exposure to problems and problem solving are needed to give staff a sense of competence and an interest in energy management. Employees must be educated to understand the need for energy conservation, the benefits of energy conservation, the principles and practices of energy management, and their own particular roles. The specific training required will vary with the individual's role in the energy management programme.

5. THE ENERGY MANAGEMENT PROGRAMME

In Chapter 2 it was indicated that energy performance of existing buildings could be improved through operational and retrofit techniques. The three basic approaches to improved operations of equipment were discussed. Chapter 3 outlined some of the basic information required to assess the potential for conserving energy and money. Chapter 4 examined some of the "people management" or behavioural considerations in energy management. This chapter discusses the basic components of an energy management programme. This should include:

(i) a day to day routine for efficient plant operation;

(ii) regular review of performance, inspection of facilities, and communication with staff;

(iii) plans for periodic upgrading of physical plant to improve energy efficiency as economically warranted (and within the constraints of human comfort).

5.1 Plant Operation

General approaches to increasing the energy efficiency of physical plant have been discussed. The most effective steps in reducing energy consumption levels are:

(i) reducing lighting levels to accepted standards

(ii) reducing ventilation rates to accepted standards

(iii) setting thermostats at moderate levels

(iv) shutting off lighting when not required

(v) reducing indoor temperatures during cool weather when rooms are not in use

(vi) shutting off ventilation systems and closing outside air dampers when rooms are vacant

(vii) maintaining the air tightness of the building enclosure system

(viii) using vestibules properly.

The applicability of these measures will depend on the actual construction and equipment of the schools being managed.

Items (i) and (ii) (checking and adjusting the systems in question) will probably require the assistance of energy management specialists. Items (iii) through (viii) will primarily be the responsibility of custodial staff, since their chief role is efficient operation of schools. Administrators and teachers may assist in improving energy performance, particularly by ensuring that lighting is used only as needed and that vestibules remain closed.

5.2 Monitoring Performance

Administrators and other school system employees are already charged with responsible application of resources, whether human, or material. In many ways, electricity and natural gas are no more unique as material commodities than pencils and erasers. The energy resource is primarily distinguished by the fact that techniques for monitoring and regulating its use are not familiar to people working in school systems. Present and future energy costs will no longer excuse ignorance of basic energy management techniques.

To ensure effective implementation of energy management procedures, administration will have to devote more attention to operation and use of facilities than has been customary in the past. Energy management is not a function which can simply be delegated to maintenance or custodial staff and forgotten. In most cases, the success of the programme will be a reflection of upper administration concern at both the school and the school system level.

A senior administrator, such as the superintendent or deputy superintendent, should be appointed as coordinator of a school system's energy management programme. The principal and/or business administrator at each school must assume responsibility for the energy management programme within his school. Only the most senior administrators have the authority and management expertise to ensure the effective functioning of an energy management programme on a continuing basis.

Administrators must convince custodial, maintenance, and teaching staff that each individual should take personal responsibility for ensuring the most efficient operation possible. Administrators must set a personal example in both word and deed. They must follow up on the progress of staff and provide encouragement as required. Energy management must be an ongoing function; it cannot be expected that one shot campaigns will produce the desired long term benefits.

5.2.1 The Information System in Energy Management

School systems will have to improve the quality of their records of energy consumption. Many systems presently maintain only a record of dollar expenditures for each building, and in some cases these expenditures are lumped together for the system as a whole. Because costs of energy are constantly changing, dollar expenditures are not reliable indicators for evaluating energy performance of buildings. Feedback from the monthly invoice accounting system is also too slow to allow the rapid response necessary for energy conserving building operation. Custodial staff in each school should read the utility meters on a daily basis. From this data base of daily readings, a weekly record of consumption can be maintained by principals or their administrative assistants.

Information of this quality is needed to:

(i) regulate operation of physical plant;

(ii) motivate building operators and other personnel to conserve;

(iii) evaluate the effectiveness of the energy management programme;

(iv) identify potential energy savings;

(v) plan conservation strategies.

5.2.2 Review of Performance and Inspection of Facilities

Statistics on energy performance of schools should be compiled regularly (on a monthly basis if possible) by the school system energy management programme coordinator. Continuing attention should be given to performance and equipment by the administrative and custodial staff responsible for each school. This is good practice not only from the point of view of efficient energy use, but also to ensure proper maintenance.

Once the energy management programme is underway and reduced levels of consumption are achieved, the energy management specialist will not be required unless energy consumption rises, energy prices increase (justifying further energy conserving measures), or construction of new facilities is contemplated.

5.2.3 Communication with Staff

Administrators must ensure that they provide information on energy use in local schools and on energy savings to other school system employees on a fairly regular basis. Frequently, only a few administrators in an entire school system are aware of the level of energy expenditures.

Administrators should regularly discuss energy management efforts with staff, particularly custodians. They should be receptive to staff suggestions about possibilities for energy savings.

5.3 Periodic Upgrading

Some physical modifications are required over time to maintain system performance. As furnace heat exchangers corrode and ductwork fails, for example, they should be repaired or replaced as part of routine system maintenance.

Other physical modifications, of the retrofit type, should be among the energy conservation measures which are considered in the economic management of energy. These may sometimes be a highly cost effective means of improving building operation - timers and similar types of controls are good examples. They can relieve manpower of needlessly repetitive tasks or of tasks which are difficult to perform with precision. Of course, the usefulness of such retrofits will depend on how easily they can be applied to the systems actually installed in a school.

Some retrofits may be required to satisfy human comfort requirements. For example, insulation of thermally inadequate exterior walls can bring internal conditions within more acceptable tolerances.

Administrators must assess necessary modifications and set priorities for expenditures. Custodial and maintenance staff can provide some assistance in this task, but the advice of energy management specialists will often be needed.

6. SUMMARY: BASIC CONCEPTS

Energy management has two primary concerns: the effective use of energy and the efficient use of energy. Effective use of energy means providing environmentally satisfactory spaces for educational processes. Efficient use of energy refers to economic rationalization of energy use. An energy management programme, based on specific information about a school system's physical plant and knowledge of environmental control will respond to both these concerns. It will include an information system on energy use and expenditures, a set of energy conserving operational practices, and a plan for physical upgrading of facilities. Implementation of the energy management programme will require training and organization of employees, with primary attention given to administrative, custodial, and maintenance staff.

6.1 The Role of Energy Management Specialists

The energy management specialist can provide a level of expertise in energy management which is seldom available within a school system. This expert can help a school system avoid costly and frustrating trial and error approaches to improving energy performance. Unlike regular school system employees, his sole concern is energy. Being an outsider, he can spot problems which have become so familiar to local staff that they are ignored rather than rectified. He can also provide senior administrators with a more objective view of their operations than they would receive from an internally conducted survey.

Initiation of energy management, as well as ongoing efforts, will require the expertise of specialists in several instances, including:

(i) analyzing energy use and identification of potential energy and dollar savings;

(ii) design of appropriate energy management programmes;

(iii) provision of in-service training to staff;

(iv) assistance in the implementation of conservation measures;

(v) assistance in reviewing energy performance and inspecting facilities.

The cost of the energy management specialist's services will be repaid many times over in energy cost reductions which will increasingly benefit the school system as energy prices escalate.

GRANDE PRAIRIE PUBLIC SCHOOL DISTRICT: RESEARCH PROJECT REPORT

Grande Prairie Public School District is typical of Alberta school systems in its goals and organization. A 1978 map of the city shows one elementary school in each quadrant of this city of 19 000. The three buildings used for instruction at the junior high level are grouped around the Administration and Maintenance building near the centre of town. An academic and vocational high school lies at the northwestern perimeter. The district teaching staff numbers 200 and serves 3350 students. A noninstructional staff of 80 deals with general administration of the school district and maintenance of physical plant.

Grande Prairie itself lies north of the 55th parallel in Alberta's Peace River District. The mean annual temperature of 1.4 °C (MOT, 1975) serves as a reminder that the local climate is severe.

Expenditures for energy amounted to about $200 000 in Grande Prairie's 1978 budget of $6 000 000. Approximately 80 percent of this budget is committed to salaries. Since school system budgets are based on fixed grants, utilities compete with other budget items for money. Savings in utility expenditures are therefore much more significant to a school system than cursory examination might reveal.

A survey undertaken by the Grande Prairie Public School District administration revealed that Grande Prairie faces energy prices which are presently among the highest in Alberta. The district's expenditures for electricity have risen from $55 000 in 1973 to $110 000 in 1976. If the $55 000 increase had been available for other purposes, it could have hired needed maintenance staff, funded special programmes, and secured other benefits. More disconcerting to the Grande Prairie administration was the converse implication of continuing inflation - continued erosion of the spending power of the district.

It was the spectre of these economic tradeoffs which spurred Grande Prairie School District No. 2357 to seek a means of cost control for utilities. The District administration's concern is therefore more aptly described as "dollar conservation" than energy conservation per se.

7. ORGANIZATION OF THE RESEARCH PROJECT

Among the activities which were undertaken as part of the research project were:

(i) a literature search on energy management;

(ii) involvement of school users;

(iii) data gathering;

(iv) energy management programme development and implementation.

7.1 Literature Search

Energy conservation in schools and other buildings has been the subject of numerous case studies, theoretical analyses and experimental programmes. Accounts of such work were an inexpensive and helpful guide to research and development. Material from diverse fields of endeavour shaped the energy management concept.

Information from the literature search had to be refined as field work progressed. Discussions of conservation often lacked sufficiently thorough consideration of technical, motivational, and/or organizational factors. Some discussions overlooked considerations which turned out to be of major practical importance. Seldom do authors give special consideration to climatic conditions similar to those encountered in Grande Prairie. Experimentation on site enabled the research team to assess the value of approaches proposed in the literature, and to develop apraoches suited to conditions in Alberta. An annotated bibliography appended to this report reviews some of the more pertinent documents studied in the course of the literature search.

7.2 User Involvement

Participation in planning and executing conservation strategies fostered user understanding of the problem and commitment to a concrete response. Because of their familiarity with the school system and local conditions, users were also able to provide a wealth of information germane to the project.

Six user groups were identified:

(i) students
(ii) teachers
(iii) community groups
(iv) administrators
(v) custodial staff
(vi) maintenance staff.

Each one of these groups has a different relationship to other groups and a different involvement with physical plant operation. The first four use the buildings as a stage for activity, while the latter two are charged with ensuring that the facilities remain physically functional.

The goal of the project was to minimize energy consumption, but also to maintain an environment conducive to the educational process. This may be interpreted as an environment acceptable to the occupants.

Rather than simply imposing change by directive, the research team sought to work cooperatively with the user groups. Apart from winning acceptance of the conservation programme, this encouraged user contributions. These people provided information essential to assessment of building performance, being familiar with operating histories, environmental weaknesses and architectural details of the facilities which they occupy or service.

They also participated in the implementation of conservation measures and in the collection of data. They gave the research team feedback on conservation measures, and made suggestions about possibilities for energy savings. The assistance rendered by users significantly benefitted the research effort.

The one user group (if it can be referred to as a group) not directly contacted was the collection of community groups ranging from Brownies to bingo clubs. Because of the diversity and number of these groups, time requirements for their involvement would have been excessive. Each group also spends very limited amounts of time in a building, and hence has a relatively small effect on overall perfomance.

7.3 Data Gathering

Many factors influence energy consumption rates - weather, building use patterns, building characteristics, and plant operation. Some determination had to be made of the relative impact of each of these factors on building performance. Particularly important to elucidate was the relative impact of each user group on energy consumption rates.

Monitoring and inventorying activities supplied much of the data needed to answer these questions.

"Monitoring" designates a data collection technique involving repeated observations, while "inventorying" designates data collection techniques involving observations at a single point in time.

7.3.1 Monitoring

Monitoring activities included sampling of energy consumption rates, accumulation of weather data, and observation of demands placed on building equipment.

Quantitative data on energy consumption furnished the most direct measure for evaluation of building performance. Records of consumption can be used to assess changes in performance over time and to compare relative efficiencies of several buildings. Four sources of information were available:

(i) records maintained by the utility companies for billing purposes;

(ii) records of meter readings performed at regular intervals by custodians;

(iii) records produced by automatic devices installed by the utility companies;

(iv) records produced through time lapse photography of meter dials by research team members.

Table 7.1 summarizes qualities of each of these techniques; a couple of general observations are worth noting:

(i) By using a diversity of measurement techniques, limitations of individual techniques were somewhat offset;

(ii) The metering devices must fulfill legal requirements for accuracy; error attributable to the meters themselves is negligable.

Natural gas and electricity are monitored only as they enter buildings. Records are not commonly maintained on consumption rates of individual building systems (lighting, space heating, water heating, etc.). It was usually necessary to estimate consumption rates for individual systems due to the resources needed (manpower, equipment, money) for direct measurement.

Reasonably accurate estimates of consumption rates could be made for most electrical equipment, given precise information on installed capacity and overall hourly patterns of consumption for a building. Estimates were not so easily formulated for natural gas systems. For instance, energy requirements for hot water heating are a function of many factors which cannot be directly observed (demand for hot water, leakage, and system runnning losses). Where feasible, an effort was mounted to directly measure this requirement.

More difficult to monitor was the pattern of demands placed on building systems by users (light switching, thermostat setting, etc.) according to use. Casual observations were made whenever the research team was working on site, and some structured surveys were carried out. This was adequate to draw some basic conclusions about user behaviour patterns, and was supplemented by comments from different user groups.

Meteorological data were obtained from the weather station at the Grande Prairie airport. Hygrothermographs were also located at a couple of sites to check local temperatures against those reported at the airport.

Table 7.1. Summary of advantages and disadvantages of different data collection techniques for monitoring building energy consumption.

Information Source	Advantages	Disadvantages
Utility Records	-records are available on a "monthly" basis -records must be accurate on an annual basis -the dates at which readings are made are recorded -estimated readings are marked as such	-the "monthly" interval may vary from 2 to 6 weeks -different buildings are not read at the same intervals -errors in meter readings are not uncommon -estimates are frequently substituted for actual readings
Meter Readings	-recording can occur at 24 hour intervals -all buildings can be read at the same interval	-sampling occurs only 5 days per week -the time of day at which the reading occurs varies errors in readings are not uncommon -the information was available only after the project started
Automatic Demand Recorder	-recording can occur at 15 minute intervals -the intervals are fixed -the data acquisition times are known	-equipment is available on on a limited basis -the information was available only after the project began -the tolerance of readings is limited by the available recording equipment
Time Lapse Photography of Meter Face	-recording can occur at intervals of a few minutes -the interval is known -the data acquisition times are known	-equipment is available on a limited basis -the equipment requires skilled handling at 2 to 3 day intervals -the equipment is highly vulnerable to damage

7.3.2 Inventorying

As mentioned above, data gathered through inventorying supplemented that obtained through monitoring. Members of the research team procured information on:

(i) energy consuming equipment including heating, lighting, and auxiliary systems;

(ii) school building enclosure systems (walls, windows, roofs, etc.);

(iii) equipment operation schedules;

(iv) facility use schedules;

(v) school system organization;

(vi) energy utility service tariffs.

While obtaining this information was usually straightforward, determining the impact of individual building components on energy consumption was complicated.

7.4 Energy Management Programme Development

Energy management programme development refers to the overall process of refining the concept of energy management for schools through field work. It involved:

(i) experimentation with conservation measures;

(ii) performance evaluation using information from monitoring and inventorying;

(iii) analysis of the organizational environment as it relates to energy management;

(iv) surveying and studying other Alberta school systems for purposes of comparison;

The field work was divided into stages. The first year of the project was devoted to evaluation of energy use and experimentation with energy conservation measures. In September of 1978, the second phase of the project was begun. This involved full fledged implementation of the energy management programme which had been developed from the findings of the first year of research. Responsibility for energy management was turned over to local staff, with the research team providing consultative assistance and evaluating the programme effectiveness.

8. INITIAL PROBLEM ASSESSMENT

A preliminary assessment of facilities and energy use in Grande Praire Public School District was undertaken in the spring of 1977.

It became evident that a minimized first cost approach to school construction coupled with design planning based on pre-1973 energy prices had resulted in buildings not only unsuited to local conditions, but also exhibiting characteristics inimical to human comfort, efficient energy use, and general durability.

Walls were uninsulated. Cracked expanses of concrete block and split roof membranes were evidence of unstable foundation conditions. Duct work installed below grade had collapsed, increasing loads on fan motors and constraining the supply of warm air to school rooms. Strips of light around door frames revealed apertures through which infiltration of outside air could occur.

Demands placed on building environmental control systems appeared to be excessive. Thermostats were found at settings as high as 27 °C. Spaces well illuminated by daylight were simultaneously flooded with light from flourescent fixtures. In some cases, illumination provided for corridors exceeded that provided for classrooms. Vacant rooms were found to be fully illuminated. No specific set of building operating procedures was in effect.

Administrative staff assembled further information needed to assess energy use in district buildings. Utility billing records were retrieved for each month of 1976, and calculations of energy consumption rates and costs were performed (see Tables 8.1 and 8.2). The average cost of electrical energy was found to be thirteen times the figure for

Table 8.1. 1976 energy consumption rates of Grande Prairie School District No. 2357 buildings (based on utility company records).

Building	First Year of Operation	Area (m^2)	Consumption (W/m^2)		
			Natural Gas	Electricity	Total
Avondale Elementary	1956	2 781	42.0	5.3	47.3
Hillside Elementary	1959	3 506	42.4	7.3	49.7
Parkside Elementary	1973	2 511	37.7	9.8	47.5
Swanavon Elementary	1957	2 334	60.1	8.6	68.7
Old Montrose Junior High	1950	4 083	52.8	3.4	56.2
New Montrose Junior High	1961	5 617	49.5	4.1	53.6
Composite High	1962	14 694	44.8	12.1	56.9
Administration and Maintenance	1961	1 158	51.3	5.6	56.9
Central Park Auxiliary Building	1929	874	67.1	1.0	68.1

natural gas. Total expenditure for electricity was more than twice that for natural gas. While the price paid for natural gas was comparable to rates in other regions of Alberta, the average price of electricity was approximately double the rate in Calgary and Edmonton.

Requirements for natural gas were found to range from 38 to 67 W/m^2, almost a two fold variation. Even more pronounced was the range in electricity consumption rates - from 1 to 12 W/m^2. Assessment of these figures and variations reinforced the conclusion drawn from the inspection that energy and dollar savings were feasible.

Table 8.2. 1976 energy consumption and expenditures in Grande Prairie School District No. 2357 (based on utility company records).

	Natural Gas	Electricity	Total Purchased
Total Consumption	56 600 GJ (539 000 Th)	9 600 GJ (2 690 000 kWh)	66 400 GJ
Average Consumption Rate (W/m^2)	47.8	8.2	56.0
($kWh\ m^{-2}\ yr^{-1}$)	420	70	490
Total Expenditure	$49 400	$111 600	$161 000
Average Expenditure (\$/m^2)	1.33	3.00	4.33
Average Unit Cost	0.87 $/GJ (0.0916 $/Th)	11.52 $/GJ (0.0414 $/kWh)	2.51 $/GJ

Notes:

1/ In 1976 Grande Prairie experienced 5557 Celsius degree-days of heating compared with the annual average of 6173.

2/ Total area of Grande Prairie Public School District buildings is 37 558 square metres.

3/ The utilization factor for school district facilities in 1976 was 87 percent (this is a measure of the students in attendance relative to the system capacity).

8.1 Inventory of Physical Plant

Early in the research project, a detailed inventory of physical plant was undertaken. Data, of the types outlined in section 3.1, were collected.

The eight Grande Prairie schools contain 145 main heating units supplied by a dozen different manufacturers. Two dozen model types and size ranges were discovered. This gives some indication of the rather staggering amount of information describing physical plant.

The information was generally organized by coding it on school floor plans - particularly lighting layout and capacity (power), illumination levels, equipment location, and data on thermostats (location, setting, and condition).

The two oldest buildings, Central Park and Old Montrose, differed most from the other buildings. They are both two storey structures heated by hot water systems with a single central boiler. These buildings exhibited the highest natural gas and the lowest electricity consumption rates. High rates of heat loss were attributed to infiltration around the extensive glazing and to the single glazing itself. The boilers are very old and decrepit, and the heating systems do not respond consistently to controls.

The six newer schools are virtually all single level concrete block construction, and all have forced air heating systems. All of the newer buildings have been modified in some fashion since construction. Even the newest school, Parkside, which was originally constructed with "open plan" classrooms, has been partitioned into smaller spaces.

Lighting levels at several schools were found to be excessive. In some cases, illumination levels exceeded 1000 lux (100 footcandles).

8.2 Common Building Characteristics Affecting Energy Performance

Some characteristics of the Grande Prairie schools which impair efficient regulation of energy utilization were recurrent.

8.2.1 Enclosure System Problems

(i) differential settlement of foundations (rupturing roof membranes and walls)

(ii) seasonal heaving of foundations (shifting roof and wall elements)

(iii) lack of vestibules at entrances

(iv) lack of shading to reduce solar heat gain through windows

(v) interior finishes with low reflectivity (reducing the effectiveness of lighting systems)

8.2.2 Space Heating System Problems

(i) inadequate controls and inadequate zoning in classroom areas (causing excessive and uncontrollable variations in room temperatures)

(ii) air intakes for unit ventilators situated so as to be below the usual depth of snow

(iii) very cramped mechanical rooms (impeding maintenance and repair of equipment)

(iv) furnaces wired so that only tandem operation is possible (preventing the shut down of one unit in warmer weather)

(v) inadequate heating systems in shop areas

(vi) collapsed ducts in below grade areas

(vii) corroded furnace heat exchangers

8.2.3 Lighting System Problems

(i) blacked out skylights (to allow use of audiovisual equipment, but preventing the use of natural light)

(ii) large variations in illumination levels within classrooms

(iii) mercury vapour lighting systems (less energy efficient than fluorescent systems and more difficult to operate efficiently)

8.2.4 Control System Problems

(i) inaccessible location of switches and controls (impeding energy efficient operation of motors)

(ii) poor design of controls (thermostats exposed to public abuse, especially at the high school)

8.3 Equipment Operation Schedules

Lighting was typically operated from between 07:00 and 08:00 until between 18:00 and 22:00. In many cases, classrooms were occupied for only 60 percent of this period.

The only timed regulation of building space conditioning equipment before the project was initiated was performed by a clock on the exhaust fans at Parkside School. These are set to operate from 08:30 to 16:30 Monday to Friday. However, members of the research team, during site visits, observed the timer to be as much as 3 days out of sychronization (a weekly clock could not be more inaccurate than this).

Although the large multizone units at the Composite High School are equipped with similar clocks to permit automatic night setback of interior temperatures, the timing tabs had been removed by the maintenance staff so that the equipment operated continuously at full capacity. The explanation offered was that winter power blackouts caused problems with the timing. However, when the frequency of such blackouts was verified with a representative of Alberta Power Ltd., the researchers were informed that such occurrences were extremely rare.

Again, the maintenance staff claimed that equipment was regularly shut down during the summer months. However information obtained from utility records refuted this assertion, at least in part. Site inspections during the summer of 1978 revealed one building (there may have been more at other times) in which ventilating system motors had not been switched off, although the building was not in use and the custodial staff were on vacation.

Domestic hot water at all schools was found to be between 50 and 60 °C at the faucet (for most purposes 45 °C is adequate).

Most vestibule entrances were not used properly; interior doors were usually propped open. This was in some cases attributable to the use of vestibules as multifunctional spaces, and in other cases attributable to inadequate heat supply to vestibules. Equally often, it was merely a case of inadequate attention to effective use of these thermal buffers.

8.4 Plant Maintenance Schedules

Checklists were found to exist for each school for the following activities:

(i) lubrication of motors and fans at three month intervals
(ii) cleaning of filters at one month intervals.

These tasks are performed by custodial staff in each school, and verified by the supervisor of maintenance through random checks. Some heating units, particularly in the Composite High School, can be reached only by erecting a scaffold. It is doubtful whether these units are frequently serviced.

One maintenance man (according to the maintenance supervisor) dismantles and services heating units in the summertime. However, with 145 units to attend to, the frequency of service is necessarily limited.

8.5 Facility Use Schedules

The Composite High School and the other schools are used with quite different intensities.

The Composite High School is staffed by at least one custodian twenty-four hours a day, six days per week. Activities run throughout the building from 08:30 to 22:00 during weekdays, although utilization is lower in the evening. Night courses are taught in both vocational and academic areas, while sporting facilities are in frequent use for training and competition. The gymnasia and cafeteria are the only spaces used with regularity on weekends.

The other schools are used from 08:00 to 17:00 for academics, and from 19:00 to 22:00 for community activities (usually a few evenings per week on a regular basis). Custodial staff open and inspect schools around 07:00, and close them between 18:00 and 22:00 depending on the daily schedule. Evening use of these schools is almost always restricted to the gymnasia and public areas.

Activities at all schools are scheduled by individual administrators at each school, and use of facilities is usually supervised by regular custodial staff.

Cleaning is scheduled to occur between 16:00 and 18:30 at the elementary schools, and between 16:00 and 22:00 at the high schools.

Apart from these regular functions, other activities, such as socials and open houses, occur at more random intervals.

8.6 School System Organization

Grande Prairie Public School District, like most school systems, has a hierarchical management structure, illustrated in Figure 8.1.

Administrators are largely recruited from the teaching staff. Exceptions are the maintenance supervisor, the district business manager and secretary-treasurer, and the high school business administrator. As a result, the interest and orientation of the administrative staff is almost entirely toward the educative function. This is reasonable in view of the chief purposes of the school district, but has some drawbacks in terms of energy management and plant administration in general: the maintenance function tends to be regarded as a necessary appendage

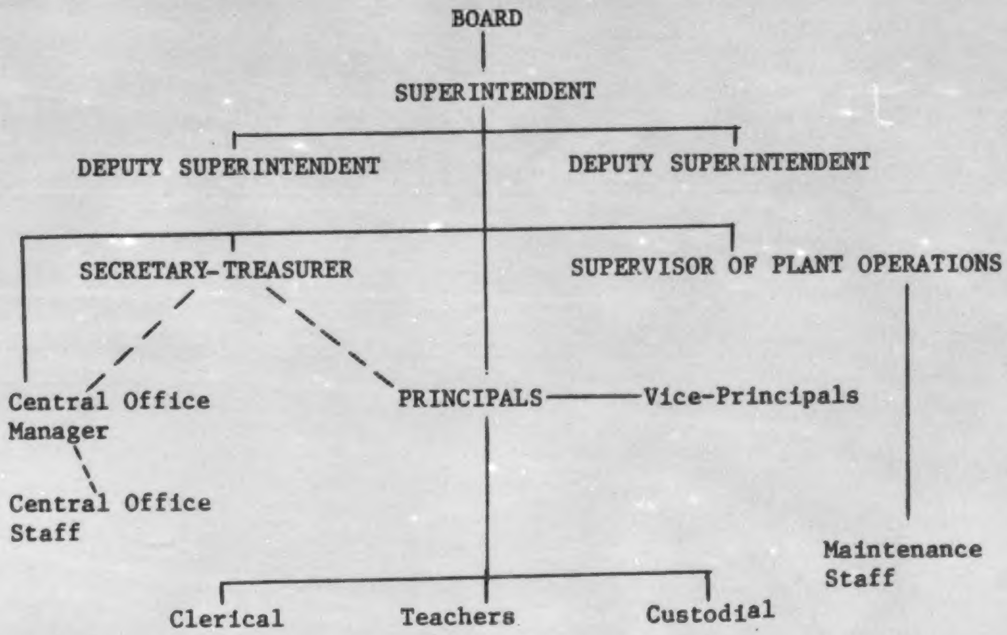
BOARD
SUPERINTENDENT
DEPUTY SUPERINTENDENT
DEPUTY SUPERINTENDENT
SECRETARY-TREASURER
SUPERVISOR OF PLANT OPERATIONS
Central Office Manager
PRINCIPALS
Vice-Principals
Central Office Staff
Maintenance Staff
Clerical
Teachers
Custodial

Figure 8.1 Grande Prairie School District No. 2357 administrative organization. The chain of authority is delineated by solid lines. Broken lines indicate some of the lines of communication and cooperation.

but not a direct and continuing concern of the administration. Energy price trends merit a reevaluation of management priorities in this regard.

8.7 Summary

Observations made during the inventorying process revealed repeated examples of inefficient functional planning in terms of both maintainability and energy utilization.

The particular systems installed in the Grande Prairie schools restricted the range of conservation measures which could be employed. Since heating and ventilating systems are not differentiated at most of the schools, curtailment of hours of operation does not offer the potential for savings it does in many buildings. These systems had to be kept operating continuously in colder weather to ensure durability of building components (due to high heat loss rates through uninsulated concrete block walls).

Features of buildings also restrict the use of intermittent operation as a conservation technique, even in warmer months. Problems with switches, as described above, impede the effective control of building equipment by building operators.

Other conditions, such as the unstable foundation conditions complicate the implementation of more permanent changes to improve performance, such as sealing of the building envelope. These problems are discussed in more detail in the following chapter.

Opportunities for conservation were noted in more conservative operation of lighting systems.

It was evident from the inventory that there is a need for improved functional planning, design, and construction of school buildings.

9. IMPLEMENTATION: YEAR I

9.1 User Involvement

At the onset of the project, three sets of seminars were organized. They had the same basic themes but were varied to emphasize the interests of the particular user group to which they were addressed - administrators, teachers, and custodial and maintenance staff.

The seminars for teachers were presented once to the academic staff of each school. The seminars for administrators (mainly principals) and custodial/maintenance staff were held once for an assembly of each group. The seminars dealt with the nature of the project and its purpose, the reasons for conserving energy, the work to be undertaken, and possible contributions by each user group. It was particularly emphasized that conservation measures were to be applied in a reasonable manner, that they were intended not to be disruptive, and that implementation of the programme should be carried out cooperatively. Users were encouraged to voice their concerns at the seminars and were assured that the research team would listen to any future comments from users.

Questionnaires were subsequently distributed to teachers soliciting their opinions on a number of items, both to provide information and to reinforce their belief that the research team was sincerely interested in listening to their views. Administrators, head custodians, and maintenance staff were interviewed frequently (about 12 contacts per individual) during the first year of the project. Principals and custodians, being in daily contact with teachers and students, were able to provide information on the reactions of these individuals as the project progressed. Numerous additional contacts were also made with teachers as they were encountered in the schools during site visits.

9.2 Monitoring

Once basic information had been gathered on the characteristics and energy utilization of the Grande Prairie school buildings, it was necessary to begin testing of conservation measures.

The limitations of utility invoices as records of building performance have already been mentioned (see Table 7.1). The lack of existing high quality data posed a problem in evaluating measures, since a precise record was required to thoroughly evaluate the benefits of conservation measures. A programme of daily meter readings (excepting weekends and holidays) was instituted in October of 1977, and was continued for the duration of the project. Custodial staff in each building recorded meter readings on forms specially designed by the research team. By the middle of October learning problems had been overcome and a four week control period was initiated to obtain a baseline measure of building performance. During this period building users were specifically asked not to change their behaviour. As a further control the users of the three junior high school buildings (the Old Montrose, New Montrose, and Central Park Schools) were requested to continue habitual practices for the remainder of the year. Implementation of the first electricity conservation measures was initiated after the first week, and implementation of the first gas conservation measures was initiated after the seventh week of the daily meter reading programme.

More detailed monitoring of energy consumption was undertaken at two sites: Parkside Elementary School and the Composite High School. Parkside School was the least complicated building to study, facilitating the interpretation of results. The Composite High School, because of its large size, plays a major role in determining overall district performance.

Northwestern Utilities Limited (the natural gas supplier) and Alberta Power Limited were requested in October of 1977 to install continuous recording devices on gas and power entries at the two schools. By February of 1978 instruments had been installed in all the desired locations.

It turned out that the natural gas consumption recorders could not record fine enough intervals and quantities to satisfy the research team's information requirements. As a substitute, a limited amount of time lapse photography of meter dials was undertaken by the research team.

Computer listings of data generated by the electrical survey units (which record on magnetic tape) were received in May of 1978. These enabled the researchers to undertake a detailed study of electricity consumption patterns.

To obtain a better understanding of subsystem energy demands, domestic type natural gas meters were borrowed from Northwestern Utilities and installed on two hot water heaters at the Composite High School and one at Parkside.

Results obtained through monitoring are discussed in Chapter 11.

9.3 Conservation Measures

Measures were implemented with the cooperation of administrators, custodial staff, and teachers.

9.3.1 Electricity Conservation Measures

From the inventory it was evident that lighting and motors constituted the major electrical loads, each accounting for about half of total electricity consumption.

9.3.1.1 Lighting

Parkside School, because of its relatively high electricity consumption rate, was selected as the initial test case for conservation. It had an installed electric capacity of 35 W/m^2 (310 kWh m^{-2} yr^{-1}) of which 24 W/m^2 (210 kWh m^{-2} yr^{-1}) was lighting. Two windowless classrooms were reduced to a minimum of 540 lux (50 footcandles) of illumination (the GSA recommended standard) by removing 50 percent of the flourescent tubes. Teachers complained that although there was no problem with "visibility", the rooms "felt dim" at this lighting level. Fixtures were restored until teachers were satisfied. This occurred at about 650 lux (60 footcandles) and 16.8 W/m^2. The perceived dimness probably was an effect of the room finish - relatively dark rough-textured panels and the lack of an exterior view.

The remainder of Parkside School was adapted to lighting levels equivalent to those in the test rooms. Teachers subsequently commented that although they noticed the change, it did not cause any problems.

At this point other elementary schools were adapted to the 540 lux level of installed lighting. These schools were generally painted lighter colours with a higher reflectivity (such as yellow). Under such conditions, even in windowless classrooms, teachers had no complaints about dimness at the reduced lighting levels.

Corridors were also reduced to accepted illumination levels where possible. Corridor lighting has a greater influence on weekly electricity consumption than its installed capacity might suggest. Some of this lighting is active twenty-four hours a day, seven days a week for security purposes. Corridor lighting of any type is usually in operation for more hours than any other lighting in a school building.

Ballasts in fluorescent fixtures from which both tubes had been removed were disconnected by the district electrician. This is necessary both to save energy (each ballast requires more than a 12 watt power supply) and to maintain a good power factor.

The second step in cutting electrical consumption was to reduce the time over which lighting was used. Custodial staff in elementary schools were accustomed to operating all lighting from 07:00 to 18:30. This routine was changed so that teachers switched on lights as they arrived in their class, and shut them off as they left. Teaching staff were encouraged to minimize the use of lighting (at recess, lunch, etc.).

9.3.1.2 Circulating Systems

Ventilating motors could not be shut down since the ventilation and space heating systems were one and the same.

The Old Montrose School is the only building with an independent ventilating system. Apart from being a control building, the maintenance staff had found from experience that components of the ventilation system drive units (mounted in roof housings) freeze up in colder weather if left idle overnight during the colder months. Another problem was that some equipment could only be switched from locations on the roof, while other motors could only be switched with circuit breaking equipment.

9.3.2 Natural Gas Conservation Measures

9.3.2.1 Aquastat Setback (Domestic Hot Water Supply)

Reduction of aquastat setting was a simple matter except at the Composite High School. Here each hot water system served a diverse group of functions (cafeteria, shower rooms, beauty culture, shop areas), some of which required higher temperature hot water. Others were so far removed from the heater that lower temperature water leaving the heating unit arrived at its destination at too low a temperature.

9.3.2.2 Permanent Thermostat Setback

Thermostat setback can be either permanent or short term (overnight, weekend, etc.). Permanent setback usually produces greater energy savings. However, inadequately insulated walls prevented the use of this measure. Just as sitting before a hot fire in cold air can provide warmth, sitting near a cold wall in warm air can cause discomfort. The measure of this effect, called Mean Radiant Temperature, was only 11 °C in some classrooms (compared with acceptable levels of 18 °C and higher); this condition occurred with indoor temperatures of +22 °C and outdoor temperatures at -20 °C (average weekly temperatures were at or below -20 °C for 6 weeks during the 1977-78 school year). Comfort problems were confirmed in the course of interaction with teaching staff.

Apart from deficiencies in mean radiant temperatures, excessive air infiltration was observed to cause discomfort in some classrooms; these drafts become increasingly aggravating as temperatures drop further below freezing. In one classroom, an air temperature difference of 4 °C was observed to obtain across the width of the room.

These findings led the research team to the conclusion that no permanent thermostat setback was possible within the constraint of maintaining conditions for human comfort. Therefore none was attempted.

9.3.2.3 Intermittent Thermostat Setback

Setting back thermostats at night and during other periods when the schools are vacant was another possibility. Due to the construction of the buildings in Grande Prairie and the severe climate intermittent setback presented something of a problem. Burst plumbing caused by freezing is not an uncommon occurrence in the school buildings during the winter (pipes are frequently routed along uninsulated exterior walls), and lowered internal temperatures increase the probability of such occurrences. The unit ventilators and fan motors are exposed directly to air temperatures of -30 °C on many winter nights. If thermostats are reduced and furnace idle time increased, components run a greater risk of being frozen. This occurs from time to time even without thermostat setback, leading to burnt out motors and damaged heating units.

Nevertheless, at Hillside School (where the custodian was particularly interested in improving performance) an aggressive setback programme (night time reduction to 16 °C) was pursued after the fourth week of the control period until the end of the school year, and without mishap. Less aggressive thermostat setback programmes (reductions to 18 °C) were experimented with at the other "conservation" schools. However, pipes occasionally froze during cold periods even when thermostats had not been set back. In general, custodial staff were reluctant, because of these problems, to experiment with such measures.

Another problem encountered with intermittent thermostat setback was the long "recovery time" required to bring some classrooms back to comfort conditions. Due to the lack of insulation and the thermal inertia of the concrete block walls, these classrooms could not be restored to comfort conditions for a few hours after morning readjustment of the thermostat. In fact, some rooms could not be maintained at comfort levels even with no thermostat setback.

While thermostat setback at the smaller schools could be managed easily by the custodial staff, the High School was not so amenable to manual control. With 70 thermostats to attend to, the custodial staff could not possibly reset temperatures in time to anticipate the first classes (the vandalism problem would prevent the use of automatic setback thermostats in most cases).

9.4 Conclusions

The range of conservation measures which could be applied was limited by the types of mechanical systems installed in the Grande Prairie schools and by the thermal properties of their enclosure systems. Further, these enclosure systems are in many cases inadequate both to maintain conditions for human comfort and to protect building components from weather effects. Working with the custodial, maintenance, and administrative staff revealed that very specific guidance is required in the implementation of conservation measures. Once routines are understood, they are usually followed with regularity as long as some evaluation of performance and feedback occurs.

Implementation of conservation measures requires interaction with users to ensure that new conditions are both acceptable and accepted.

Changes in patterns of energy consumption resulting from implementation of these measures are presented in chapter 12 and are also discussed in Chapter 11.

10. IMPLEMENTATION: YEAR II

From September of 1978, the aim of the field work was to turn responsibility for energy management over to the Grande Prairie Public School District administration and to evaluate the implementation of energy management as an ongoing school district function.

One of the Deputy Superintendents assumed responsibility for district coordination of the energy management programme. Together with the administrative assistant for maintenance, he met with school principals and business administrators to ensure that they understood the work to be undertaken. A list of needed maintenance of building systems was also compiled in the course of these meetings.

Individual school administrations continued to maintain daily records of electricity and natural gas use during the second year of the project. Weekly consumption was plotted on specially designed forms placed in public locations so that awareness of energy use could be stimulated. These charts allowed comparison of energy use with the previous year. Efficiency of natural gas use was corrected for temperature variations using formulae based on consumption versus temperature regression lines from the 1977-78 winter.

Contact was maintained with each school (by both the district coordinator and the research team), and problems relating to energy management were discussed. Bulletins were issued by the district coordinator listing the energy performance of each school and accounts of dollar savings achieved through energy conservation.

The research team continued to receive copies of utility meter recording sheets so that they could monitor energy use and check the figures calculated by school system employees.

The research team assisted the district coordinator in preparing cost effectiveness estimates for physical upgrading projects to be undertaken during the third year of Grande Prairie Public School District's involvement with energy management. Several worthwhile projects were identified. In cooperation with the district coordinator, a district policy on energy management was formulated.

Members of the research team made site visits at monthly intervals. Use of facilities (lights, vestibules, etc.) were checked during each visit. Implementation of energy management as an ongoing function was simultaneously reviewed. Further training of local staff was provided where required.

Analysis and development of the energy management concept was continued.

11. RESULTS FROM THE MONITORING PROGRAMME

The researchers collected data to determine:

(i) where, when and how energy is expended in the buildings under study;

(ii) what type of data and what kinds of indicators can be used to audit building performance;

(iii) the most effective techniques for evaluating energy conservation measures.

Although records of daily natural gas and electricity meter readings were maintained by custodial staff, weekly intervals were selected as the basic time period for evaluating performance in all schools. Weekly calculations of consumption rates benefit from the high degree of redundancy obtained by basing them on daily or near daily readings (limitations of manually obtained daily readings are outlined in Table 7.1). Precise monthly records can also be obtained from the data base of daily readings.

Automatic recording equipment, available on a limited basis, provided more precise short term records. These were needed to identify relationships between user activities and variations in energy requirements, and to obtain a better understanding of energy demands by individual building systems.

In this chapter, some results of the electricity and natural gas monitoring programme are reviewed. Electricity consumption is dealt with first.

11.1 Analysis of Electricity Consumption

11.1.1 Hourly and Daily Electricity Consumption Patterns

Electrical survey units, capable of recording requirements for electricity over 15 minute intervals, were used to obtain very precise information on patterns of consumption at the Parkside and Composite Schools.

A typical daily record for Parkside School is plotted in Figure 11.1. The base load represents 50 percent of daily consumption; on a weekly basis the base load represents sixty percent of consumption (the base load is generated by equipment which is in continuous or near continuous operation - primarily electric fan motors, but also including a certain amount of security lighting. The variable daily load (above the base load) primarily consists of lighting.

A succession of daily electricity consumption totals for the Composite High School are plotted in Figure 11.2. Over the period shown, a consistency of daily consumption rates is evident. The base load (about 2000 kWh/day) represents about 60 percent of weekly consumption.

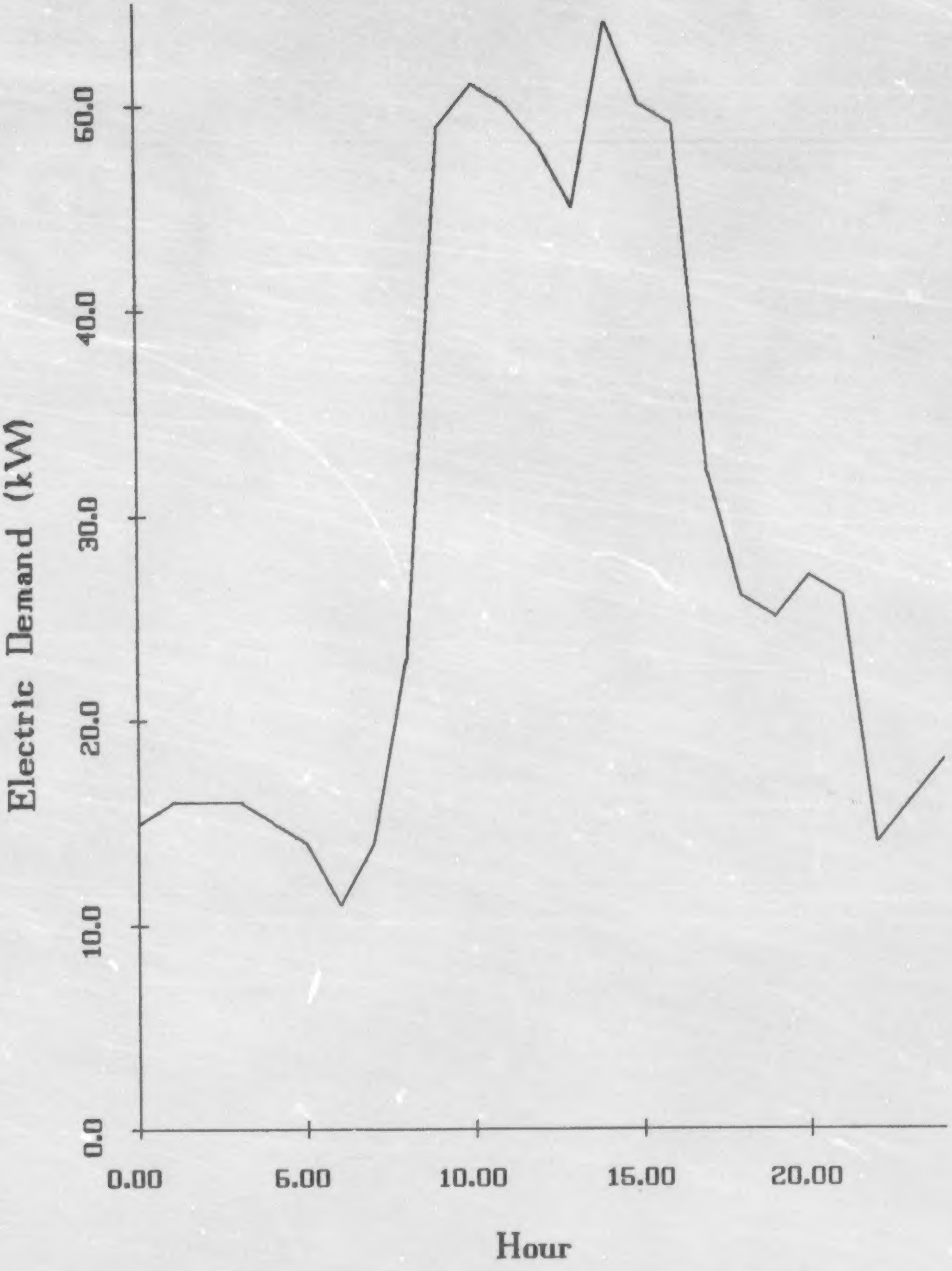

Figure 11.1 A plot of typical hourly electric demand over a 24 hour period at Parkside School.

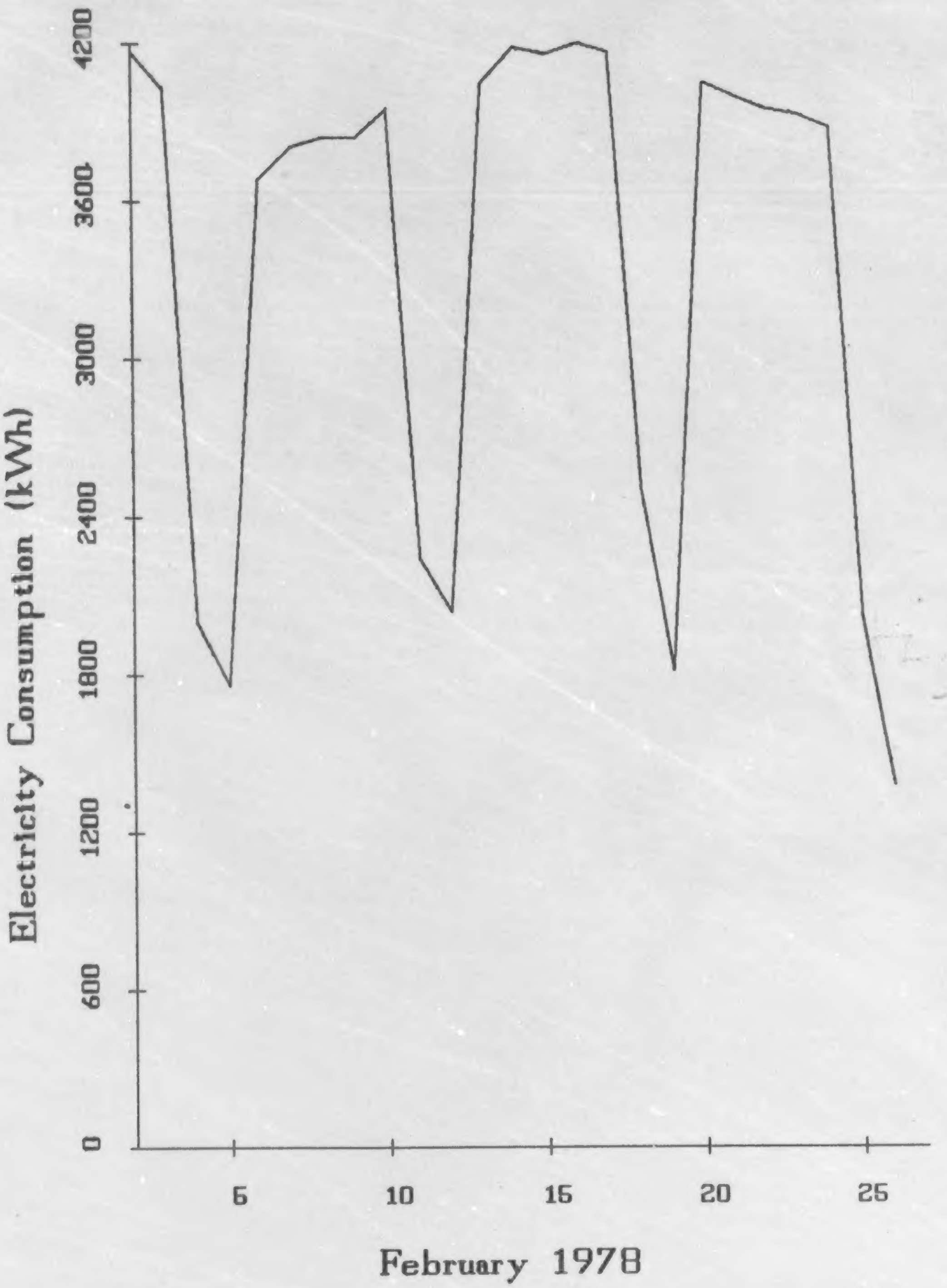

Figure 11 .2 Plots of typical daily electricity consumption at the Composite High School over a 24 day period.

11.1.2 Weekly and Monthly Electricity Consumption Patterns

Figure 11.3 illustrates weekly electricity consumption at 4 schools during the first year of the research project. Similar patterns were exhibited by the other Grande Prairie schools. The conspicuous troughs in consumption at weeks 11 and 24 are attributable to Christmas and Easter vacation periods. Comparison of monthly and weekly plots of electricity consumption rates show that increasing the measurement period can obscure significant fluctuations in performance (see Figure 11.4). Decreases in consumption rates evident in both figures are due primarily to the implementation of conservation measures.

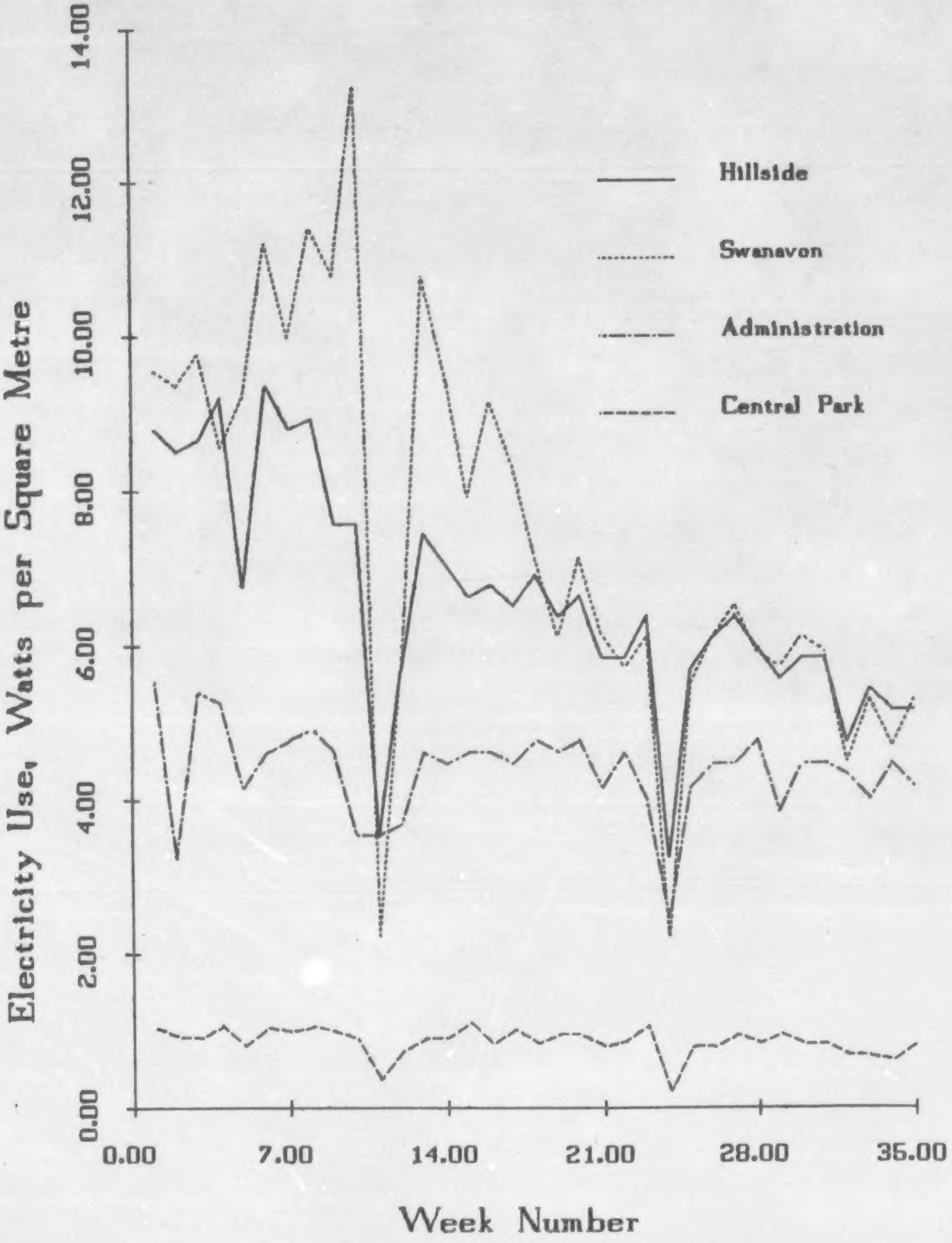

Figure 11. 3 Weekly electricity consumption rates at Hillside, Swanavon, and Central Park Schools during the research study (weekly rates for the Administration building are also plotted).

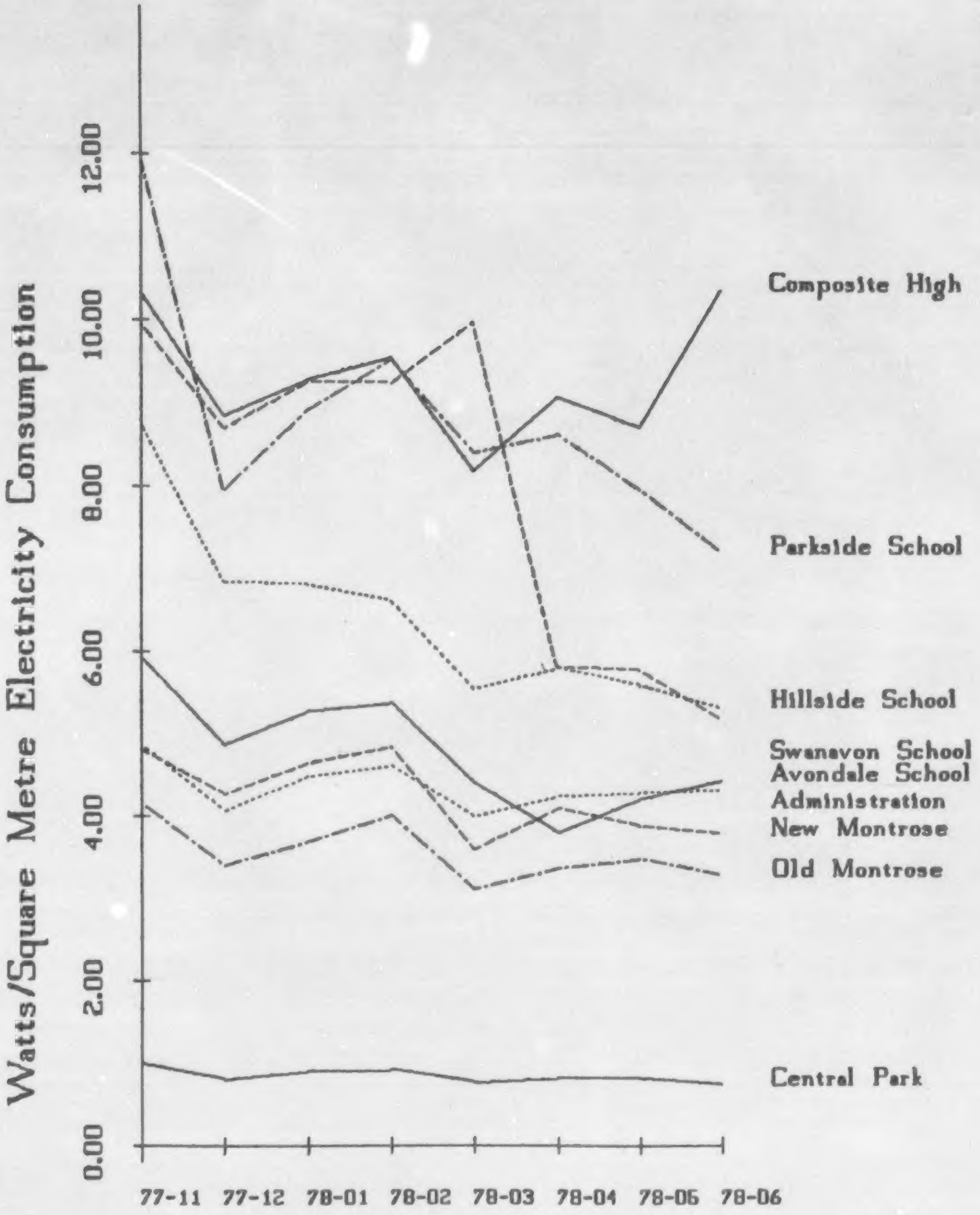

Figure 11.4 Monthly electricity consumption rates in Grande Prairie School District No. 2357 buildings during the research study.

Decreased electrical requirements were exhibited by all buildings after implementation of the energy management programme (see Tables 11.1 and 11.2). Table 11.3 shows the changes which have occurred in both electricity and natural gas costs and consumption from 1976 through 1978.

Table 11.1. Comparison of winter peak electricity demands from 1977 to 1979 (based on utility company records).

Building	Peak Electric Power Demand (kW)			Decrease	
	1977	1978	1979	kW	Percent
Avondale	48	44	44	4	8
Hillside	88	82	64	24	27
Parkside	76	60	60	16	21
Swanavon	70	72	53	19	26
Old Montrose	46	43	42	4	9
New Montrose	116	115	112	4	3
Composite	360	360	320	40	11
Administration	23	18	16	7	30
TOTAL	827	794	711	116	14

11.2 Analysis of Natural Gas Consumption

Techniques for estimating heating requirements of buildings must increase in sophistication as the complexity of the building increases. As stated in the ASHRAE Systems Handbook (1976) "a simple procedure may use only one measure, such as annual degree-days, and will be appropriate only for simple systems and applications". The school buildings in Grande Prairie are relatively simple buildings, and the dominance of heating requirements in determining overall demand for natural gas renders them amenable to less sophisticated techniques of analysis. The Systems Handbook also states "records of past operating experience of

Table 11.2. Comparison of electricity consumption before and after implementation of the energy management programme (based on 4 weeks consumption as determined from daily consumption records).

Building	Monthly Electricity Consumption (kWh)		Decrease	
	77-10-14 to 77-11-11	78-10-13 to 78-11-10	kWh	Percent
Avondale	10 920	10 320	600	5
Hillside	20 800	13 600	7 200	35
Parkside	21 000	16 560	4 440	21
Swanavon	14 640	9 520	5 120	35
Old Montrose	11 480	9 720	1 760	15
New Montrose	18 080	15 200	2 880	16
Composite	120 400	90 400	30 000	25
Administration	4 050	3 090	960	24
TOTAL	221 370	168 410	52 900	25

Note: The time intervals compared correspond to the control period in the fall of 1977 (before conservation measures were implemented) and the same period in the fall of 1978 (after the implementation of energy management).

Table 11.3. Comparison of annual energy consumption and prices in Grande Prairie 1976-1978.

	Year 1976	1977	1978	Percent Change 1976-78
Celsius Degree-Days	5 556	5 743	5 760	+3.7
Natural Gas Use (GJ)	56 600	55 400	53 800	-5.0
Natural Gas Cost - $	49 400	66 200	62 000	+20.3
- $/GJ	0.87	1.19	1.15	+32.2
Electricity Use (GJ)	9 680	8 680	6 940	-28.3
Electricity Cost - $	112 000	118 000	116 000	+3.6
- $/GJ	11.50	14.60	16.70	+45.2

the building in question, when these are available, provide the most reliable and usually the most accurate basis for the prediction of future requirements". Data on gas consumption were collected and analyzed during the first year of the project to determine how effectively such estimating of energy requirements could be performed.

11.2.1 Weekly and Monthly Natural Gas Consumption Patterns

Statistical analysis of factors affecting natural gas consumption was undertaken during the first year of the project in order to determine their relative importance (see Table 11.4). Correlation of natural gas consumption with average weekly air temperature produced an average r-squared of 0.898, while an average r-squared of 0.926 resulted from correlation with the other factors considered. This left but a small portion of the variation in consumption unexplained. Further analysis indicated that manipulation of controls and use of the building by people was probably responsible for most of the remaining variation.

Regression lines were plotted for each school (data on Parkside school is presented in Figure 11.5). From the results of the regression analysis, Table 11.5 was compiled. The reference temperature is that temperature above which supplementary use of natural gas for space heating will not be required; the magnitude of the slope of the regression line ("lossiness") is the increase in the rate at which thermal energy (and hence natural gas) must be supplied to the building per degree decline in temperature.

Table 11.4. R-squared values obtained from analysis of factors affecting variability of natural gas consumption rates in Grande Prairie School District buildings (step wise multiple regression was performed on 24 weeks of data to obtain these figures).

Building	Reference Temperature (degrees Celsius)	Lossiness (W/m^2 per degree Celsius)	Consumption Rate at 22 degrees Celsius (W/m^2)
Avondale	22.0	2.07	0.0
Hillside	21.2	2.36	0.0
Parkside	25.7	2.02	7.5
Swanavon	16.6	2.81	0.0
Old Montrose	31.4	1.97	18.5
New Montrose	19.4	2.72	0.0
Composite	22.8	2.35	1.9
Administration	22.6	2.35	1.4
Central Park	28.2	3.42	21.2
AVERAGE	26.0	2.72	5.6

(the reference temperature and the lossiness correspond to the intercept and slope of the regression line)

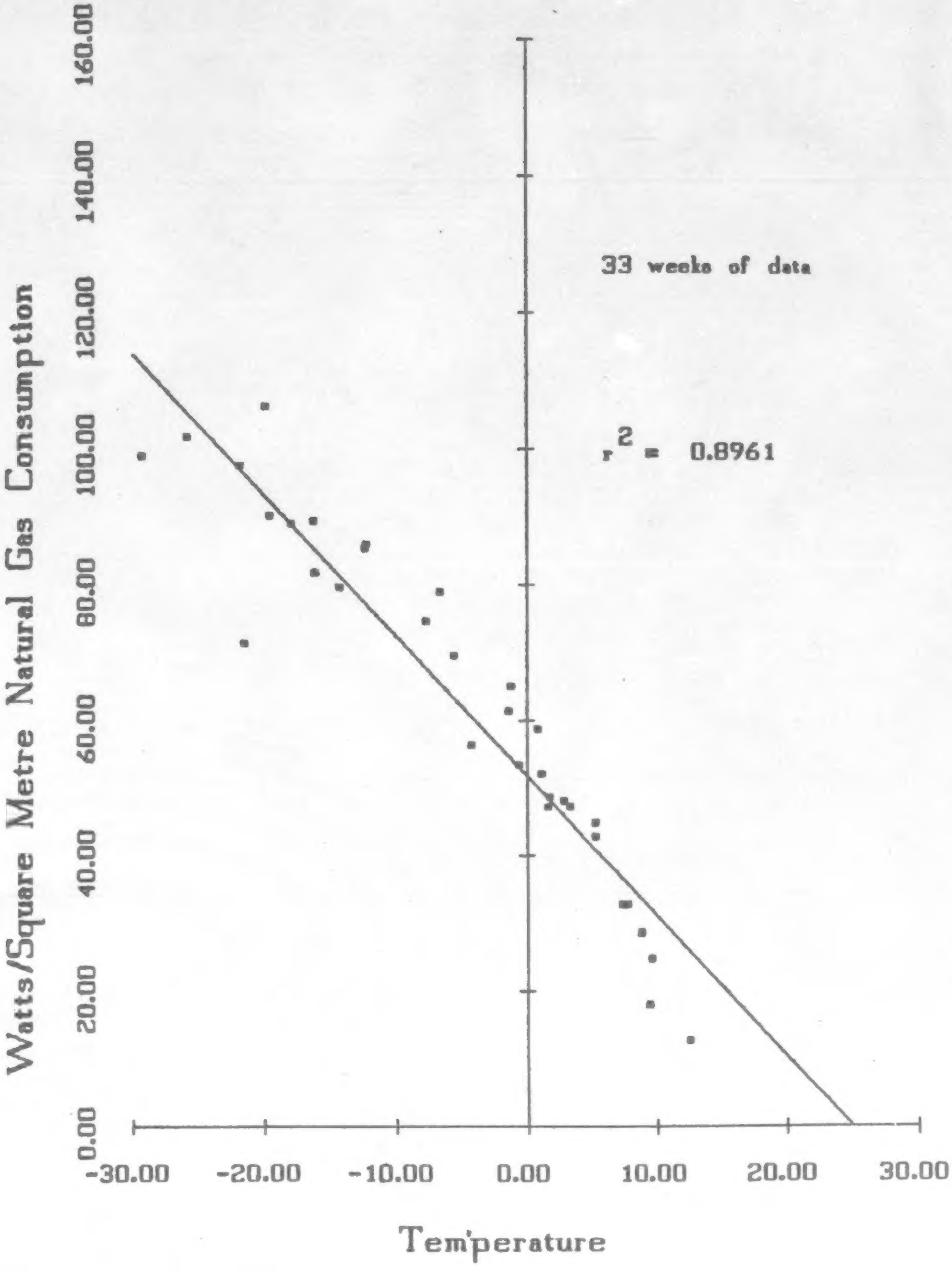

Figure 11.5 Regression plot based on weekly natural gas consumption rates at Parkside School.

Table 11.5. Results of regression analysis of data on weekly natural gas consumption rates in Grande Prairie School District buildings.

	Variable Explained				
Building	Temperature	Wind	Hours of Sun	Days School Opened	TOTAL
Avondale	0.874	0.016	0.010	0.015	0.915
Hillside	0.889	0.008	0.001	0.003	0.901
Parkside	0.853	0.034	0.017	0.011	0.915
Swanavon	0.884	0.000	0.002	0.000	0.943
Old Montrose	0.921	0.001	0.002	0.000	0.923
New Montrose	0.975	0.007	0.000	0.001	0.976
Composite	0.945	0.002	0.003	0.001	0.952
Administration	0.849	0.002	0.004	0.007	0.880

The reference temperature assumed for calculation of standard degree-days is 18.0 °C. It is evident that this reference temperature does not match any of those obtained through regression analysis. This means that degree days of heating will provide a less than optimal correction for the effects of exterior temperature on energy needs.

The regression data collected during the first year of the project were used to develop a heating requirement prediction formula for each school. This formula was employed by the principal at each school during the second year of the project. It allowed the user to calculate the predicted weekly energy consumption of a school, given the average weekly temperature. This predicted consumption could then be compared with the actual consumption to determine whether performance was better or worse than in the previous year.

A performance indicator (the ratio of the actual to the predicted consumption) was plotted graphically in conspicuous locations to increase awareness of performance. However, given the problems involved in implementing natural gas conservation measures, the relatively small dollar and energy savings to be achieved by factors under the control of the building operator, and the effort to initiate and maintain this information system, such elaborate techniques cannot be justified for routine operations (at least, not in Grande Prairie).

11.2.2 Evaluation of Natural Gas Performance

Evaluating reductions was more complicated for natural gas than for electricity, due to the magnitude of the reductions possible and the magnitude of variations caused by weather and building use patterns.

Since a control period was instituted in the first year, before conservation measures were implemented, and since control buildings were employed after implementation, it was possible to develop Table 11.6. Four sets of data are presented for each of the control and conservation groups. The first set corresponds to the period before any conservation measures were implemented. The second set corresponds to the same period, but excludes one week due to the abnormally high gas consumption rates experienced at four schools (all in the conservation group - this was the first week of extremely cold weather, and gas use rose to levels higher than during much colder periods later in the school year). The third set covers the period when conservation measures were in effect. The fourth set also covers this period, but excludes midwinter weeks in

Table 11.6. Statistical information based on data from monitoring natural gas use.

Data Set	R-squared (Average Weekly Temperature)	Reference Temperature (degrees Celsius)	Lossiness (W/m^2 per degree Celsius)
Control Group			
I Weeks 1-7	0.949	23.9	3.08
II Weeks 1-5,7	0.894	20.8	3.01
III Weeks 8-33	0.959	26.4	2.68
IV Weeks 17-33	0.921	22.9	3.11
Conservation Group			
I Weeks 1-7	0.969	21.2	2.81
II Weeks 1-5,7	0.937	20.5	2.89
III Weeks 8-33	0.946	20.9	1.98
IV Weeks 17-33	0.922	19.6	2.48

which temperatures much colder than those in the control period were experienced (to avoid making the conservation results look "too good").

Taking the "worst case" (from the conservation viewpoint), from period II to period IV, control buildings exhibited a 2.1 °C increase in reference temperature and a 3.3 percent increase in lossiness. Over the same periods, conservation buildings exhibited a 0.9 °C decrease in reference temperature, and a 14.1 percent decline in lossiness. The latter drop in reference temperature is noteworthy, since it was achieved in spite of a reduction in heat gain from lighting in the conservation period (one would normally expect the reference temperature to rise when supplementary heat gains from interior loads are reduced since a greater burden is placed on the heating system).

Due to the deterioration of heating equipment (cracking of heat exchangers and collapsing of ductwork), comparison of performance over the two years of the project could not be undertaken with a great deal of accuracy. Based on the data which was gathered, it is our best estimate that savings were in the order of 5 to 10 percent overall (in the sense of energy use avoided rather than total reductions from previous years), with some variation from building to building.

12. OBSERVATIONS AND CONCLUSIONS

12.1 Energy and Dollar Savings in Grande Prairie

During the project, electric demand was reduced by 14 percent and electricity consumption by 25 percent. This was largely achieved through removal of fluorescent tubes, disconnection of ballasts, and use of "phantom" tubes. More efficient use of lights by staff accounted for about one quarter of total electricity savings. The ultimate potential reduction in electricity consumption could be as high as 40 percent, if all opportunities for savings were acted on. While some opportunities for further reductions in demand remain, it is doubtful whether an overall reduction exceeding 20 percent could be realized. Reductions in electricity use to date have a dollar value of about $21 000 per annum if improved performance is sustained. No capital expenditures were required to achieve these savings.

The approximately 5 percent reduction in natural gas utilization would have an annual value of about $2500. This was achieved through more efficient operation of plant by custodial staff and by improved maintenance.

The overall reduction of energy expenditures is therefore about $23 500, or 14 percent of current annual expenditures. Achieving substantially greater savings would require major capital investment in modifications to buildings and equipment.

It would be relatively easy for other school systems in the province, on average, to also save $20 000 or more per annum through improved operating practices. With approximately 140 school systems in

Alberta, the total saving would amount to almost $3 million in 1979 dollars, and the value of the saving would increase as energy prices escalate.

12.2 Energy Savings Potential

An energy budget of 28.5 W/m^2 (250 kWh m^{-2} yr^{-1}) has been established by the federal government as a design guideline for new buildings. Alberta schools, on average, use about 52.5 W/m^2 (460 kWh m^{-2} yr^{-1}), 47 W/m^2 (410 kWh m^{-2} yr^{-1}) being natural gas and 5.5 W/m^2 (48 kWh m^{-2} yr^{-1}) being electricity. However, there is substantial variation from building to building. The question arises as to how closely existing buildings can be brought to performance levels expected of new buildings. This will depend on the specific characteristics of each building, but some general estimates can be made, based on the field work.

In Grande Prairie, it was found that schools consuming less than 5 W/m^2 (44 kWh m^{-2} yr^{-1}) of electricity generally offered few opportunities for substantial reductions in electricity consumption. This is approximately the minimum level of consumption required to provide adequate lighting and to operate ventilating fans. For the same reasons, 5 W/m^2 would also appear to be the limit to improved performance for higher consumers. There are no retrofits which could alter this requirement.

Reductions in natural gas consumption through changing operating schedules offered only a small potential for savings (10 percent being the upper limit). In other buildings with different types of enclosure systems and air-conditioning systems, it might be possible to achieve more significant reductions in natural gas consumption than was possible in Grande Prairie. More substantial reductions in natural gas consumption should be possible through retrofit of buildings. Insulation of concrete block walls, for example, could reduce consumption rates by 20 to 40 percent. This could reduce average consumption to about 34 W/m^2 (300 kWh m^{-2} yr^{-1}) yielding an overall energy consumption rate of 39 W/m^2 (340 kWh m^{-2} yr^{-1}) - about 40 percent higher than the budget for new buildings, but 25 percent lower than current performance. Attaining this level of performance would require major capital expenditures.

In other buildings with different types of enclosure systems and air-conditioning systems, it might be possible to achieve more signiificant reductions in natural gas consumption than was possible in Grande Prairie.

12.3 Implementation of Energy Management

School systems benefit significantly from the assistance of energy management specialists in implementing energy management programmes. The reasons are:

(i) lack of local expertise in analyzing energy utilization;

(ii) administrative activities which are assigned a higher priority;

(iii) the need for a motivated and knowledgeable person to ensure that conservation measures are implemented as they should be.

Maintenance and custodial employees of the school district work subject to the following priorities:

(i) critical repair jobs (to keep the buildings operational)

(ii) modifications for safety (during the Grande Prairie Energy Management Project, the local fire marshall ordered $130 000 worth of modifications)

(iii) important renovations (including energy conserving modifications)

(iv) other projects

Implementation of energy conserving adjustments to physical plant may require several months, according to the availability of manpower. Intermittent, but sustained, contact with the energy management consultant helps to ensure that necessary modifications are fully implemented over the long run.

A more detailed discussion of the role of the energy management specialist is provided in Chapter 6. The energy management specialist would also be needed in the follow-up process (see 5.5). His trained eye is needed to detect problems less evident to the layman. His continued involvement is needed to prevent energy management from being "lost in the shuffle" of other administrative concerns, which can happen even with the best-intentioned administrative team. During the first year of the programme, a visit once per month to each school might be required. During the second year, two or three visits might be required. Once lower levels of energy consumption are achieved the energy management specialist need only be brought in should levels of consumption rise (this would be indicated by the monitoring system), or if building construction or modifications are being planned. Over time, a large reservoir of trained manpower would be built up.

12.4 Building Operation and Retrofit

Although school operation and retrofit were investigated by independent teams, both approaches should be employed as energy management tactics. Economic, technical, organizational, and institutional constraints will dictate where and when specific energy conserving measures will be implemented.

Adjustment of building operation does not involve any significant capital expenditures, while capital costs of retrofit measures vary widely. Where an expenditure for a retrofit measure may be worthwhile, the cost effectiveness of the measure must be investigated. The usual criteria is whether the cost of energy saved over a given time period (usually about seven years) will equal or exceed the cost of the retrofit measure. However there are other factors which should be considered when a retrofit measure is contemplated.

12.4.1 Specific Evaluation

Specific evaluation of each proposed retrofit measure is required to assess financial feasibility. A measure which is uneconomic for one building may be attractive for another. Among the points to be considered are:

(i) actual energy consumption of the building system being studied;

(ii) physical characteristics of the building and building system being studied;

(iii) local utility rate structures and prices (including projected increases);

(iv) estimated service life of the building.

12.4.2 Human Comfort

If schools do not meet basic standards for human comfort (as discussed in Chapter 1), they should be upgraded to an adequate level of performance. Work carried out in the past under Alberta Education's Building Quality Restoration Programme (such as installation of new lighting systems) has been based on this constraint.

Some of these measures to meet human comfort requirements simultaneously reduce energy consumption. Insulation, duct maintenance, and furnace maintenance are examples.

Modifying buildings to satisfy comfort requirements will require interaction with the building users.

12.4.3 Expenditure and Work Load Balancing

While the payback period for retrofit measures is an important factor in evaluating economic benefit, there are other factors which may involve equally significant costs.

If a school system waits until a retrofit measure offers an attractive return on investment, it may face a sudden large budget requirement to pay for upgrading (since the measure is likely to become financially attractive for several buildings at once). On the other hand, by immediately beginning to implement retrofit measures which have up to twice the usual payback period (say fifteen years), the work and costs can be spread out over a longer period. This would help to forestall a sudden drain on revenue.

Another advantage of incremental retrofit, is that in-house labour could be employed on such projects when it is not engaged in other tasks. In this case, the only "real" cost to the school system would be the cost of materials.

12.4.4 Retrofit and Operational Savings

Savings from a retrofit measure are usually estimated solely in terms of the potential direct energy savings to be achieved by the measure. However, retrofit measures may also make additional energy savings through possible operational adjustments.

For instance, the value of insulating is based on the reduced cost of natural gas due to reduced heat flow through walls. Other savings do become possible once the retrofit measure is undertaken. In most of the Grande Prairie schools, possibilities for permanent and intermittent thermostat setback were limited by the high heat loss rates of the concrete block walls. By adding insulation, these operational measures for conserving energy could be implemented, providing additional energy savings. Wall insulation would also protect plumbing and other building equipment, reducing manpower and material costs of repairing weather damaged building components.

These additional energy and dollar savings made possible by retrofit measures should be considered in evaluating retrofit feasibility.

12.4.5 Staff Expectations

Employees frequently expect that in return for their efforts to conserve energy, the school system will upgrade building systems or components which are seen by staff to be wasting energy and/or causing discomfort.

This viewpoint was expressed by many employees in Grande Prairie who felt that dollar savings from more conservative use and operation should be "ploughed back" into upgrading of the schools.

12.5 Impact of School Users on Consumption

12.5.1 Electricity

The only significant control teachers and students have over electricity consumption is the switching of lights. Some energy savings can be realized where rooms are not in use for the entire day. Relatively large savings can be realized when daylighting (through skylights) can be substituted for artificial lighting and in vocational shops where large amounts of lighting can be switched off when not required (as long as these measures are pursued on a consistent basis).

Outside school hours (08:00 to 16:30), custodial staff can save large amounts of electricity by switching off lights before and after classes (outside the immediate work area). Careful use of lights during these times can reduce overall daily electricity consumption by 10 to 15 percent.

Adjustment of lighting levels is usually carried out by custodial staff, with appropriate professional guidance.

An equally significant conservation role for custodians could lie in the operation of building equipment. During warmer months (September, October, April, May, and June), substantial energy savings could be achieved by switching off heating/ventilating systems at night. If such systems are operated from 07:00 to 17:00 Monday to Friday only, a 70 percent reduction in weekly base load could be realized.

12.5.2 Natural Gas Consumption

The savings in electrical energy to be obtained by switching off heating/ventilating units during summer months would be complemented by a saving in natural gas.

Such extreme measures cannot be applied during cooler months. However, in a classroom, even in mid winter, lighting and human body heat contribute about 75 percent of space heating requirements. Raising thermostats during this period does not, therefore, significantly increase daytime natural gas consumption. The real penalty is incurred if thermostats are left at settings higher than 20°C for the 120 hours per week that classrooms are unoccupied. Custodial staff can play a major role by ensuring that thermostats are set to reasonable levels at 16:30.

Reducing air leakage from schools by caulking and weatherstripping is the task of maintenance and custodial staff. Reparing and maintaining equipment is also the responsibility of these two groups.

12.5.3 Community Use

It was determined that community use of schools in Grande Prairie accounted for no more than half of one percent of annual utility costs (about $1 000).

12.6 Highlights

Recapitulating the report, the most important points are:

1. School systems can achieve major energy and dollar savings through implementation of a carefully designed energy management programme.

   In Grande Prairie Public School District, the annual saving from energy management has an estimated value of $23 500 (1979). The adoption of similar programmes by all Alberta school systems would result in annual savings in excess of $2 million, with no capital investment required. The annual value of energy savings from improved operating practices would increase as energy prices escalate.

2. Energy management programmes must be developed individually for each school system.

Energy management is a process not only of modifying buildings, but also of training staff. Each school system has a unique set of people who must be introduced to energy management concepts. Based on experiences in Grande Prairie, an interactive learning process with energy management specialists appears to be the most effective approach. This means that contact with energy management specialists is very important. While this contact time will usually be spread over an extended period (as much as two years), its total duration per school can be relatively short - in the order of four days from initial assessment through final follow-up.

As well, because Alberta school buildings vary so greatly in construction, energy management programmes must be tailored according to the characteristics of the individual school building. The usefulness of a conservation strategy based on a typology of school buildings and generic recommendations for improved operations is limited.

3. A systematic approach should be used in developing an energy management programme for a specific school system.

The steps are:

(i) appoint an energy management coordinator for the school system;

(ii) analyze energy utilization and identify potential savings in energy expenditures;

(iii) analyze the local organizational environment and manpower capabilities;

(iv) design an appropriate energy management programme;

(v) provide basic instruction to staff (including teachers) on energy management - the how's and why's of conservation;

(vi) organize for energy management on a continuing basis;

(vii) implement specific energy conserving measures.

4. The support and cooperation of all school system personnel should be solicited when implementing an energy management programme.

Only this will gain the acceptance of conservation measures by staff and so increase the effectiveness of the programme. Staff and students must be made aware of the general aims and objectives of the programme. It must be made clear that adequate levels of comfort will be maintained. Concerns of staff should be heard and responded to, since expectations play an important motivational role in energy management.

5. The energy management programme should be seen to have the full endorsement and active support of senior district administrators.

This is necessary to establish the credibilty of the programme and to motivate staff and students. In Grande Prairie, a deputy district superintendent assumed responsibility for coordination of the programme.

6. Effective involvement of custodial and maintenance staff is key to a successful ongoing energy management programmme.

Custodial and maintenance staff play a greater role than any other group in determining the day to day energy performance of schools.

7. An energy use monitoring programme based on daily energy meter readings is necessary both to control performance and to stimulate awareness.

Senior administrative staff in Grande Prairie confirmed the value of the monitoring programme as a motivational and management tool.

8. Specialized expertise is required to set up an effective energy management programme for a school system and to recommend specific energy conserving measures for its buildings.

The use of energy management specialists is highly cost effective. It is strongly recommended that Alberta Education establish a group capable of providing ongoing energy management support to school systems.

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Dubin, S.E., Mindell, H.L., and Bloome, S., 1976. How to Save Energy and Cut Costs in Existing Industrial and Commercial Buildings . Noyes Data Corp., Park Ridge, New Jersey, USA. 700 pages.

This book contains a comprehensive discussion of energy management for buildings. Many specific types of low cost energy conservation measures are presented in concise case studies. Some organizational considerations in energy management are also reviewed. Because this book is a general work intended to cover all building types, it may be found unwieldy by the less specialized staff of smaller school districts. However, it is an excellent reference for the professional plant manager and the engineer.

Fugate, J.L., 1977. Energy Conservation in Schools. Unpublished bachelor's degree thesis, Department of Mechanical Engineering, University of Manitoba, Winnipeg, Manitoba. 72 pages.

Energy conserving measures which can be applied in schools are discussed, and the potential for dollar and energy savings at one Winnipeg school is investigated. While the importance of an organizational foundation for energy management is recognized, it is accorded only a couple of paragraphs. The report is based solely on theoretical calculations; no implementation or applied evaluation of conservation measures was undertaken.

Lagerway, R.A., 1978. Methods of Energy Conservation in Winnipeg Elementary Schools. Unpublished master's thesis, Natural

Resource Institute, University of Manitoba, Winnipeg, Manitoba. 97 pages.

An energy utilization analysis was undertaken for two elementary schools. Many observations are in accord with those made in Grande Prairie. Excessive levels of illumination, inefficient operation of building systems, and user attitudes were among the problems noted. Detailed analysis of heat loss is undertaken, since the study examined all possibilites for energy conservation from operational changes through major modifications to buildings.

R-values (insulation values) of the walls of the two schools studied ranged from 2 to 6 times the R-values of _any_ school wall in Grande Prairie. This probably explains why comfort problems of the type encountered in Grande Prairie were not encountered in the course of this study.

Only one page of the report is devoted to organizational aspects of energy management. However, the remainder provides a clear basic analysis of energy utilization in the two schools studied and of the potential for conservation.

Apparently, no attempt at implementing conservation measures was undertaken, since no discussion of this aspect of energy management is presented.

Leblanc, E. A., 1977. _Energy Sourcebook for Educational Facilities._ Council of Educational Facility Planners International, Columbus, Ohio. 400 pages.

Organizing for energy management in school systems is discussed in detail. Based on American experience, the approaches which are proposed are more appropriate to very large school systems (such as those in Calgary and Edmonton) than to more typical Alberta school systems. Experiences in Grande Prairie would indicate that some of the organizational structures suggested are excessively cumbersome. This manual would probably be of more assistance in planning for energy management from the provincial perspective than from that of the typical Alberta school system.

Tuma, S.L. and Dunwoody, J.E., 1977. Establishment of an Energy Conservation Management Program in Illinois Schools. Illinois Department of Business and Economic Development, Springfield, Illinois (US Department of Commerce National Technical Service Document PB-271 730). 57 pages.

A clear and concise guide to the rudiments of energy management, including both organizational and technical concerns. Much of the technical discussion is based on a typology of Illinois schools, and hence may not be directly applicable to individual Alberta schools.

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This series of ten handbooks covers all aspects of commercial energy conservation. Certain handbooks contain discussions relevant to school systems ("First Steps", "Saving Money in Heating, Cooling, and Lighting"). The material, although clearly presented and comprehensive in scope, is general, and hence is not geared specifically toward the conditions and problems relevant to Alberta schoool systems.

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GLOSSARY

Celsius degree-days - the difference between the mean daily temperature and 18.0 degrees Celsius when the mean daily temperature is below 18.0 degrees Celsius; used as a measure of heating requirements.

footcandle - a measure of the light falling on a square foot of surface area (replaced by lux)

insolation - the radiant energy received from the sun by a surface

lossiness - the increase in the rate of supply of supplementary heat required by a building per degree drop in outside temperature.

lux - an SI measure of the light falling on a square metre of surface area

reference temperature - the average exterior temperature above which a building will not require supplementary heat for space conditioning.

retrofit - the physical upgrading of a building to improve its energy utilization.

specific energy need - purchased energy consumed per unit of gross floor area per annum.

LIST OF ABBREVIATIONS

ASHRAE - American Society of Heating, Refrigeration, and Air-conditioning Engineers.

CEFP - Council of Educational Facility Planners

cfm - cubic feet per minute

EMR - Energy, Mines and Resources Canada

GJ - gigajoule (10^9 joules)

hp - horsepower

IES - Illuminating Engineering Society

J - joule

kW - kilowatt

kWh - kilowatt-hour

MCF - thousand cubic feet (of natural gas)

NRCC - National Research Council of Canada

OEC - Office of Energy Conservation (EMR)

SI - System International

W - watts

APPENDIX A: MEASURES FOR SAVING ENERGY

I Human Management Practices (for administrators)

1. Work cooperatively with users in the implementation of measures.

   A note of caution must precede the recommendation of the following measures. For the sake of brevity, they are stated rather tersely. These measures are maximum initiatives to be taken; their implementation must be tempered with a knowledge of circumstances in each building - user circumstances must be considered. The most effective means of dealing with such circumstances is by delegating responsibility for specific implementation of measures which will affect local users to the local school administration.

   To give some concrete examples of specific considerations which would require some thought before measures could be adopted, measures 2.1 (night time thermostat setback to 13.0 degrees Celsius) and 3.3 (morning thermostat reset to 20 degrees Celsius) will be discussed. It is evident that special provisions would have to be made for tropical fish and other temperature sensitive animals kept in schools when the former measure is implemented. The latter measure is not to be considered an absolute dicta of the daytime temperature - it is simply anticipated that users could readjust the thermostat to preferred settings upon arrival, but that this setting would place classrooms on the boundary of the air temperature comfort zone.

   To gain acceptance, measures used to conserve energy must accomodate user preferences (within reason).

2. Monitor people's efforts and give them specific feedback on their performance.

3. Assign people specific responsibility for their work spaces.

   3.1 Teachers should see that classroom lights are switched off when rooms are vacant (recess, noon, after school).

   3.2 Shop instructors should selectively switch lighting when only portions of their shops are in use. Exhaust hoods should be operated as little as possible in winter, late autumn and early spring. During cold weather, use of exterior doors should also be minimized. Equipment should be operated in an efficient manner.

3.3 The evening cleaning crew should set thermostats at night time levels at 16:00.

3.4 The day crew should set thermostats at day time levels during the morning round of classroom checks (at 07:00).

3.5 Thermostats enclosed in protective cases should be checked weekly, where possible.

3.6 Staff should attempt to be economical in setting thermostats. Wearing a sweater is frequently preferable to turning up the heat.

4. Publicize the energy conservation programme and results of energy consumption monitoring so that all groups within the schools are aware of efforts and achievements.

II Seasonal Operation Practices

1. Summer

1.1 Shut off all space heating systems.

1.2 Shut off hot water heating systems where possible.

1.3 Shut off ventilating systems for unoccupied areas.

1.4 Shut off air-conditioning for unoccupied areas.

1.5 Minimize use of electric lighting systems.

1.6 Operate air-conditioning from 10:00 to 15:00 only in occupied spaces during work days.

1.7 Set internal temperatures at 22 degrees Celsius or higher when air-conditioning is operating.

2. Fall/Spring (September-October/April-June)

2.1 Set thermostats back to 13 degrees Celsius daily at 16:00.

2.2 Set thermostats to 20 degrees Celsius at 07:00 each morning that classes are held.

2.3 In air-conditioned spaces operate the cooling system from 10:00 to 15:00 only during working days.

2.4 Maintain temperatures in cooled spaces at 22 degrees Celsius or higher.

2.5 Shut off ventilation systems daily at 16:00 (this may be delayed for gymnasia and other areas used into the evening).

2.6 Turn on ventilating systems at 08:00 each morning that classes are held.

2.7 Ensure that corridor thermostats are never set above 18 degrees Celsius.

3. Winter (November-March)

3.1 Ensure that no thermostats are set higher than 20 degrees Celsius when schools are not in use (check daily at 16:00).

3.2 Where pipe freezing, motor burnout and other hazards do not exist, set thermostats back to 16 degrees Celsius daily at 16:00.

3.3 Set thermostats to 20 degrees Celsius at 07:00 each morning that classes are held.

3.4 Shut off air cooling systems.

3.5 Ensure that corridor thermostats are never set above 20 degrees Celsius.

4. Year-round

4.1 Substitute daylighting from windows and skylights for electric lighting where feasible.

4.2 Minimize use of electric lighting systems. Lights should be turned off in all unoccupied areas at all times.

4.3 During cleaning lights should be used only in the working area.

4.4 Ensure that all windows are firmly closed (check daily at 16:00).

4.5 Ensure that both outside and vestibule doors are firmly closed (check daily at frequent intervals, especially after periods of heavy traffic).

4.6 Ensure that leaking hot water taps are repaired.

III Maintenance Practices

1. Electrical

1.1 Reduce illumination levels where acceptable, but maintain minimum standards:

- 540 lux in classrooms
- 110 lux in corridors
- 760 lux in shop areas

Maintain an even distribution of light.

1.2 Ensure that burnt out lights are replaced immediately.

1.3 Ensure that luminaires are cleaned monthly.

1.4 Replace existing flourescent tubes with low watt tubes (but maintain minimum lighting standards)

1.5 Reduce parking lot lighting to minimum levels required for safety.

1.6 Use proper size motors.

1.7 When redecorating, use light colours to achieve higher illumination levels.

2. Mechanical

2.1 Ensure that controls are calibrated and in good condition.

2.2 Clean air filters monthly.

2.3 Lubricate motors and other rotating equipment monthly.

2.4 Adjust outdoor air dampers for tight closure.

2.5 Adjust heating and cooling equipment to ensure maximum combustion efficiency.

2.6 External door tension should be removed so that doors will not stay open.

2.7 Clean strainer screens in water circulating systems at two month intervals.

2.8 Reduce air duct leakage.

3. Structural

3.1 Caulk window and door frames. Caulk cracks in walls.

3.2 Install weather stripping around windows and doors where not subject to excessive shifting.

3.3 Repair/seal broken windows.

APPENDIX B: ENERGY MANAGEMENT PROGRAMME ORGANIZATION

District Functions

- receive and assess weekly reports on energy consumption from each school
- produce and distribute district monthly energy use reports to the Board and to each school (including cost estimates)
- ensure that energy management measures are being implemented at each school
- provide technical assistance in implementing energy conservation measures
- obtain the mean daily temperature from the weather office, calculate the weekly average, and provide this figure to the schools
- check school energy consumption (monitor meters) at month end in June, July, and August
- ensure that equipment is switched off in July and August

School Functions

- read natural gas and electricity meters every school day
- keep track of weekly energy performance
- evaluate whether performance is satisfatory based on records of energy use and the activity schedule for the building.
- implement energy conservation measures
- ensure that all staff are aware of their responsibilities vis a vis energy management
- maintain plots of weekly natural gas and electricity consumption indicators in the main entrance foyer of the school